DDT—Killer of Killers

BY

ZIMMERMAN AND LAVINE

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DDT—KILLER OF KILLERS

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DDT
KILLER OF KILLERS

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Chapter One

Man's Mortal Enemies

Man Conquers The Louse

THE AMERICAN ARMY was in action. It had recently established its beachhead at Salerno and was now fighting its way up the Italian peninsula. Then signs of disaster appeared! It was not a reinforced German Army or an Italian Army suddenly inspired to put up a fight. No, it was the lowly louse or, more specifically, millions or billions of lowly lice.

In all the previous wars of history, the louse had killed more men that had ever died from bullets, swords, or other weapons. Would this war be a repetition of the history of the past? Would lice stop the advancing American Army and kill thousands of our fighting men? Things looked black! Over a million poverty-stricken people were crowded into the city of Naples—a population without fuel, water, or light; a terror-stricken population crowded together in air-raid shelters; a population covered with lice. And lice carry that dreaded disease—typhus.

It was the month of October in the year 1943; and that month the hospitals of Naples received 25 typhus cases. To all who know that dreaded disease, this was an ominous sign, for throughout all the years of history whenever typhus had broken out at the beginning of winter, it had never been brought under control until the warmer weather of March or April had arrived. When typhus cases increased to 40 a day in December and to 60 a day in January, and people were dying in the gutters of Naples, it was evident to all that a full-scale epidemic had arrived, and that by February—unless something drastic could be done—500 people a day would be coming down with this disease of uncleanliness.

The American soldiers had been vaccinated against typhus, but it was impossible to vaccinate the entire population of Naples. Realizing the seriousness of the situation, Brigadier General Leon Fox, Field Director of the American Typhus Commission in Cairo, flew to Naples to see what he could do. General Fox knew about the magic new wonder killer *DDT* and how it had protected our troops against lice during the invasion of Africa. He decided to use it in an experiment of tremendous magnitude. In the month of January alone, 1,300,000 people in Naples were dusted with DDT powder, and as more refugees entered the city they were immediately given this treatment. The typhus epidemic passed as rapidly as it had started—by the middle of February it was completely under control. This was the first time on record that a typhus epidemic had been stopped in mid-winter; and for the first time in history that scourge of war—typhus—had been licked.

The Battle of the Centuries

Man, throughout the countless centuries since he first appeared on earth, has gradually managed to fight his way to the top of the animal kingdom. The giant mammoth and dinosaur exist only as skeletons in museums; the tiger and the lion hide in the deep jungle or the bushy veldt, away from the powerful firearms that man's ingenious brain has devised to make up for his lack of physical strength. But the outcome of that age-long battle between mankind and the insect world is still uncertain.

At times the insect hordes get the upper hand, and millions of human beings drop dead from the poison injected into their bodies by mosquitoes, lice, fleas, or ticks, while others die through eating food poisoned by the ubiquitous fly as he makes his daily round from the manure pile, the privy, or the garbage can to the kitchen table. But even these deaths, horrible as they may be, are no worse than the millions of other deaths due to famine, caused all too often by the incessant appetite of insects for the same food that man consumes. According to Dr. P. N. Annand of the U. S. Department of Agriculture, destruction of crops by agricultural insects costs United States farmers two billion dollars a year, or as Dr. L. O. Howard puts it, devastation by insects undoes the work of a million men.

At other times, man gains a significant victory over his enemies. He concocts a vaccine to neutralize the effect of an insect's bite; he destroys the breeding grounds of his assailants; or he develops a poison that wipes out the insects faster than they can breed. But the latter is a difficult task, for birth control is certainly not practiced by our tiny foes. Newborn insect children can look forward to becoming parents in a few days or even a few hours; and, although human quintuplets make the headlines throughout the world, an insect mother who produced only five offspring at a time would hang her head in shame at this evidence of her virtual sterility.

More Destructive Than Wars

In World War II—the most recent of the many conflicts in which man has killed his fellow man—the toll of human life was staggering. The American forces alone counted almost 400,000 dead, including those who died from natural causes and behind-the-lines injuries. Among the Russian and German Armies, the dead must have numbered in the millions; and additional millions were added to the list by the other belligerent nations. This is the penalty we paid for not learning how to get along with each other; but it is only part of the penalty, for no one can estimate the sum total of human suffering that this one war brought about—the agonies of the wounded, the loss of homes and means of livelihood, the starvation and disease, the bereavement of the survivors, and the hopeless outlook for the future. These are the penalties that men have paid throughout the ages for their periodic wars against members of their own species.

We should not attempt to minimize the tragedy of war, for wars are senseless and useless, but from an impersonal point of view we must admit, for the sake of accuracy, that insects have killed many more men and have caused much more human suffering than have all the wars of history. And in addition, mosquitoes, lice, and fleas have decided the outcome of most of men's wars, and have thus played a bigger role in shaping the political history of the world than have all our military men and statesmen. In fact, World War II—thanks to the medical services and DDT—was the only major war of history in which diseases transmitted by insects did not play a decisive role.

The Black Death

Diseases—hundreds of them—are always with us. But most of the time they attack only a small proportion of the population at a time. But not always! Every once in a while the pages of history have been blackened by pestilences that have spread throughout whole populations, attacking almost everyone and killing high percentages of those so afflicted. And of the many pestilences that have left their trail of dead and dying and human suffering, none has struck more terror into the hearts of men than has that dreaded disease, bubonic plague—the most terrible epidemic of which was the infamous *Black Death* of the 14th century. The Black Death, however, was not the only serious epidemic, for there had been a number of outbreaks of plague before the 14th century, and there have been a number since.

In the 6th century, during the reign of Justinian I, the last of the Roman Emperors, plague came out of the Orient and struck Constantinople in the year 532. It soon spread to Italy and the rest of Europe, and killed half the population of the Roman Empire. Shortly thereafter the Roman Empire collapsed, and its collapse was due, at least in part, to the widespread changes brought about by the ravages of the plague.

But for widespread destruction, the epidemic known as the Black Death is in a class by itself. Introduced into Constantinople from Asia in the spring of 1347, it quickly spread through Greece and the Mediterranean Islands, reached Sicily in October, passed on to Naples, Genoa, and Marseilles—where four-fifths of the population are reported to have died—and reached Dalmatia before the end of the year. It was well established in southern France, Italy, and Spain early in 1348, reached Paris by June, and was in England and Ireland by the fall of the year. Shortly thereafter Germany and the Netherlands felt the attack, and by the year 1350 this pestilence had spread throughout all of Europe, even to the distant islands of Iceland and Greenland.

When the cold, clammy fingers of the Black Death touched a community, few inhabitants escaped. In many towns and cities, more than half the population died. The total number of deaths throughout Europe is hard to believe. At last 25,000,000 people—one-fourth of the population of Europe—were killed by this visitation of the plague, and some authorities place the total deaths as high as three-fourths of the whole population.

But even this destruction of human life did not satisfy the demon of the plague, for it returned again and again to many parts of Europe over the next thirty years. In many regions, one-third of the population was wiped out in 1359 and 1360; and many Polish towns lost one-half of their populations in 1360 and 1361. Ten years later, in 1370, Russia was revisited by a severe wave of plague that killed 80,000 people in Lubeck alone.

During the next two or three centuries, plague epidemics broke out every once in a while, and although they were not as severe as the Black Death itself, they would all be classified as major calamities if they were to occur in 20th century America. For example, it has been estimated that in Paris alone bubonic plague killed 50,000 in 1418, 40,000 in 1450, and another 40,000 in 1467. Other cities fared just as badly: there were 16,000 plague deaths in Florence in 1418; 40,000 in Constance in 1438; 30,000 in Venice in 1477 and 1478, and 18,000 in Vienna; while in Brussels, in 1502, as many as 500 a day lost their lives.

Except for minor, localized epidemics, plague was relatively unknown from the 16th century to the year 1871, when it broke out in the Chinese province of Yunan-Fu and soon spread to surrounding areas. By 1894, when it reached Hong Kong, it was a serious epidemic, and when it arrived in India it killed six million inhabitants of that country in a period of ten years.

From India the plague spread to the sea ports of all the continents of the world, and the United States had its first taste of this disease in 1900 when it reached San Francisco. The United States' epidemic of plague spread fear throughout a population that was well aware of what had happened in other parts of the world when plague became established; but the worst fears were not justified. The total number of recorded deaths was only 314, most of which were reported from California although eight other states contributed to the total. Undoubtedly, the number of unreported plague deaths was much greater than the number reported, but even if we allow for these, this epidemic was a far cry from the Black Death of 14th century Europe. Nevertheless, everyone breathed a sigh of relief when, in 1904, there were indications that this outbreak of plague had died out.

Unfortunately, the United States did not get off as easily as it seemed at the time. Plague is here to stay; and some day, if we are not careful, the black, distorted features of victims of bubonic plague may become commonplace in the cities of America. We will explain this a little more fully later, but first we should tell you how this disease is spread.

Rats, Fleas, and Plague

Throughout the centuries that plague ravaged the earth, all efforts to control the spread of the disease were ineffective because no one knew its cause or how it was spread. People a few hundred years ago were not appreciably different from folks today, and they reacted to the unknown in practically the same manner. Some accepted the plague as punishment from an angry God and turned to religion for their salvation. Others felt that there was no hope and threw themselves into all forms of dissipation in attempts to squeeze the maximum amount of pleasure from their few remaining days. And, as further evidence that the world hasn't changed much, some blamed the plague on the Jews, and thousands of unfortunate members of this race, particularly in southern Germany, were burned to death in their homes. This 14th century persecution—like persecution of the Jews today—often had its practical aspects. Many noblemen owed money to the Jews and used the plague as an excuse for eliminating their creditors. However, the mass of people knew in some vague way that the disease could be transmitted only by some physical means; and those who could afford it fled from the towns and cities at the approach of an epidemic and avoided as much as possible contact with the sick and dying. Very often, even flight and quarantine were ineffective: castle walls could not keep out the Black Death.

It had often been observed, even in ancient days, that large numbers of rats died during epidemics of human plague. But the role of the rat in the transmission of plague was not discovered until the present century. The disease itself is caused by a specific bacillus, first discovered in 1894 during the plague epidemic in Hong Kong. It was later demonstrated that plague is primarily a disease of rodents, particularly rats; and in 1906 the British Indian Plague Commission proved that the bacillus is transmitted from rats to man by the bite of the flea.

Actually there are two forms of the disease: the true bubonic plague, which one gets when he is bitten by a plague-carrying insect; and the pneumonic plague, in which the bacillus is carried directly from one person to another by means of infected droplets. But, since the pneumonic form is merely an outgrowth of the bubonic form of the disease, as long as there are rats to act as a reservoir for plague and as long as there are fleas to carry the plague to man, the possibility of tragic epidemics will always be with us.

It is probable that most epidemics of human plague started when fleas from plague-infested wild rats transferred their place of abode to house rats, and the fleas from the house rats, upon the death of their hosts, jumped over to people. Yet, there is evidence that the rat flea is not the only culprit. Cat and dog fleas, fleas on wild and domesticated birds, and even bedbugs and lice may, under some conditions, play a part in the spread of the disease.

And that brings us back to the San Francisco epidemic of 1900. This epidemic, as was mentioned before, had run its course by 1904, at least as far as anyone then knew. But only on the surface. Among the hordes of rats it was still smoldering, and worse yet, it had spread from the rats to other rodents—ground squirrels, rabbits, chipmunks, prairie dogs, etc.—as was discovered in 1906. Since then, plague has been found in wild rodents in all of the western states, and in many parts of the east. So far, only a few cases a year of human plague have been reported, and in all cases the victims were campers, hunters, and children who came in contact with the wild rodents. But now that the war is over and more and more people are vacationing in the wide-open spaces, will the number of plague cases increase? Or will fleas from the infected wild rodents carry the disease to our city rats and then to the human population? Will plague sweep this country as it did Europe in the 14th century? We don't know the answers yet. But if the worst does come, we will have only ourselves to blame. Unlike the inhabitants of medieval Europe, we know how plague is spread. We can't pass it off as an act of God. We know that we must beware of the flea. He's an ugly looking beast, and his bite is worse than his appearance.

Lice, Fever, and Death

Next to bubonic plague, the most dreaded of European pestilences is *typhus,* also known as ship fever, camp fever, jail fever, and spotted fever. Traditionally, this is the disease that for centuries has followed in the wake of armies. World War II was no exception, but thanks to DDT, vaccines, and the greater cleanliness of modern armies, typhus for the first time in history was brought under control.

As was the case with bubonic plague, hundreds of years elapsed before man found out how typhus was spread. It was not until 1909, when Charles Nicolle discovered that typhus is transmitted from man to man by lice, that the mystery was stripped from this disease and men learned that there was more to body cleanliness than merely the elimination of body odor. People who change to clean clothing once a week won't harbor body lice, and if these individuals take a bath before putting on their fresh garments, so much the better. But only a small percentage of the world's population can boast of a standard of living so high that it permits of a change of garments and a bath tub. When people are crowded together in concentration camps or in city slums, when homeless, underfed refugees drag their weary bodies through the rubble of bombed-out cities, lice move in to feed on the anemic blood of the unhappy individuals.

Since typhus is transmitted by lice, it is easy to understand why waves of typhus have devastated Europe and Asia for hundreds of years. The first bath tub was introduced in to America in about 1840, and for years thereafter many prominent medical men of the day wrote learned tracts and made impassioned speeches about the dangers of bathing. The Saturday-night bath did not become an American tradition until many years later, and even then many reactionaries continued to resist this revolutionary idea. Imagine what conditions must have been like in Europe in, say, the 15th, 16th, or 17th century? Practically no one bathed, and everyone, from the poorest peasant in his filthy rags to the proudest queen with her equally filthy petticoats, was infested with crawling, biting vermin.

Typhus is one of the numerous fever-producing diseases caused by germs that are intermediate in size between the bacteria and the filterable viruses. This class of organisms is called the *Rickettsiae,* after their discoverer, Howard Taylor Ricketts, an American who, ironically, contracted typhus and died in 1910 in Mexico City while he was studying *tabardillo,* the Mexican form of the disease.

Because the symptoms of typhus are similar to those of a number of related diseases, it is impossible for the medical historian to estimate when typhus first began to change the history of the world. Many of the epidemics described by early writers might have been typhus, but the evidence is too incomplete for a proper diagnosis. We do know, however, that typhus broke out among the army of Ferdinand and Isabella during the siege of Granada in 1489-1490, and that 17,000 soldiers are supposed to have lost their lives from the disease—many more than were killed by the weapons of the Moors.

And in 1528, typhus decided the fate of Europe by entering into the battle between Charles V and Francis I for control of Italy. In 1527, the Imperial Army of Charles V marched through Italy, sacked Rome, and made a prisoner of the Pope, Clement VII, who was allied with Francis I of France. Then plague broke out in the city and killed a large proportion of the population as well as the soldiers of the Imperial Army. Even the Imperial General, Lannoy, died of the disease. The army of Francis I was not long in coming, and the decimated Imperial troops were in no condition to put up a fight. The remnants of the once-proud Imperial army managed to get to Naples where they fortified the city, and here they were besieged by the French Army under Lautrec. The surrounded army was dying of starvation and was ready to give up when typhus suddenly struck the French army of 25,000 men and reduced it within 30 days to about 4,000 survivors, at least according to some accounts. Lautrec was forced to retreat, Clement VII and Charles V patched up their differences, and, in 1530, Charles V was crowned ruler of the German Empire.

And yet, to show the impartiality of typhus, Charles V was forced to abandon the siege of Metz in 1552, when his armies were stricken with a typhus epidemic and 30,000 men died from disease.

A number of other outbreaks of typhus occurred during the remaining years of the 16th century, usually when armies were on the march—and then came the Thirty Years' War, from 1618 to 1648. Few periods of history held so much suffering for so many people. It was not the battle casualties alone, or even the atrocities perpetrated upon helpless civilian populations by conquering soldiers—and these defy all description. It was pestilences of all types, and in particular, plague and typhus, marching side by side with the armies, that accounted for the majority of the deaths and decided the outcome of many of the battles. The 60,000 deaths in Lyons and the 25,000 in Limoges in 1628 are merely examples of what took place all over Europe.

Skipping the pages of history to another decisive war, the campaign of Napoleon against Russia in 1812, we again find the louse of greater importance than the generals. Everyone has read of the dreadful suffering of Napoleon's troops when they retreated from Moscow—how men froze to death by the thousands and died of starvation. Of an army of over half a million men at the beginning of the campaign, Napoleon returned to Paris with only a handful. About 300,000 men perished from disease alone—about twice as many as died from battle wounds—and of these typhus accounted for a large proportion, although dysentery and pneumonia killed no small number.

When most of us think of the Crimean War, that took place in 1854-1856, we think of either Florence Nightingale or the "Charge of the Light Brigade." But instead of shedding too many tears over the "noble 600," let's pay our respects to the more than 100,000 who died from disease. It is impossible to say how many of these deaths were due to typhus and how many to cholera and dysentery, but reliable accounts inform us that there were two violent typhus epidemics during the war, and that they struck the opposing armies with about equal intensity.

In World War I, there were also two severe typhus epidemics, and future historians may record the fact that both played important parts in shaping the history of the world from the year 1914 on. The first outbreak occurred in Serbia in November of 1914. It started among the Austrian prisoners whom the Serbians had captured, and soon spread throughout the Serbian Army and the civilian population. In less than six months over 150,000 people had died, and Serbia was practically helpless. The Austrian Army could easily have gone through Serbia and attacked Turkey, Bulgaria, and Greece before these countries could have put up an effective resistance. But fear of typhus held them back, and the Central Powers lost their initial advantage.

Typhus flourished among the Eastern armies throughout the war, but vigorous delousing programs kept it pretty well under control among the Germans and Austrians. However, after the retreat of the Russian armies in 1916, typhus cases in Russia began to increase in number, and a full-scale epidemic, like those that had devastated Europe in the Middle Ages, was on its way. The spread of the disease was accelerated by the chaotic conditions of civil war; and between the years 1917 and 1921 there were 25,000,000 victims of typhus in the Soviet Republic, and from 2½ to 3 million of the victims died.

Because World War II passed without a major typhus epidemic, we might be inclined to assume an attitude of complacency and delude ourselves into believing that "it can't happen here!" That would be unfortunate, for there are dark clouds on the horizon. Typhus is not unknown in this country. Although there have been no epidemics of the classical European type, there have been occasional localized outbreaks of the disease. Since the typhus-infected louse can live for not over 12 days, it seemed highly improbable to students of typhus that these sporadic attacks were due to transmission of the disease from man to man by lice. They decided to investigate; and their investigations showed that typhus can be carried by household rats—and probably by other rodents—and that it is transmitted from rat to rat by rat fleas and rat lice. Of course, when a flea carrying the deadly *Rickettsiae* bites a human, the disease can become established in man, and if the victim is lousy, he can in turn pass the disease on to those with whom he comes in contact. Thus, the rat is not only the carrier of plague—he is also a reservoir of typhus. And keeping our bodies free from lice is not sufficient assurance that we will not get typhus. We must also look out for the flea.

Mosquitoes and Quinine

Many Americans who fought the war in the Pacific brought back to their native land millions of unwanted souvenirs: tiny protozoa in their red blood cells. These organisms, the germs of that debilitating disease, malaria, were introduced into the bodies of our soldiers by female members of a class of mosquitoes known as *Anopheles.* However, it is not necessary for a resident of this country to leave the borders of the U. S. A. in order to get malaria—the disease is well established in at least 36 of our states and it has been known to exist in most of the others. Although Laveran discovered the protozoa of malaria as early as 1880 and Ronald Ross discovered the role of the mosquito in the transmission of the disease in 1895, we have accomplished little in the way of mosquito control, and are still relying on quinine or newer drugs such as atebrin to make life tolerable in regions where *Anopheles* reign.

Malaria is not a disease, like bubonic plague or typhus, that kills a high percentage of those that it attacks, but it saps the strength of its victims and makes them miserable for a long, long time. Yet, even though malaria does not kill most of its victims, so many people throughout the world contract this lingering disease each year that the small percentage who die from it comprise a by-no-means insignificant total. Reliable figures are impossible to obtain, but available evidence indicates that at least 3,000,000 of the world's inhabitants die from malaria each year, and probably a hundred times that number are made ill. How many malaria victims die not from the disease itself but from other infections which gain a foothold in their malaria-weakened bodies is anybody's guess, but the total must be at least as great as the number killed directly by the disease.

That malaria has played an important part in the history of the world is beyond question. After the campaign of the Greeks against the Egyptians in 456 B.C., the soldiers of Hannibal brought back malaria, and ever since, the Mediterranean basin has been a favorite breeding ground for germ-carrying mosquitoes, waiting to pass on the disease to those who dare enter their domain. The mosquitoes lost no time in spreading malaria among the Greeks in those long-passed days. Before long, the population was so weakened by germs in their blood cells that Greek civilization was on the down grade, and the Greeks were in no condition to withstand the arms of the Roman legions.

The movement of armies has always been a big factor in the spread of malaria, as the Crusaders, the troops of Napoleon, and the British Tommies all found out. In our own Civil War, over 50 percent of the white troops and over 80 percent of the negro troops fell victims to malaria each year; and our Spanish-American soldiers found malaria a more formidable enemy than the Spaniards. Incidentally,

FIG. 1. DR. PAUL MÜLLER, WHOSE EXPERIMENTS LED TO THE DISCOVERY OF THE MAGIC INSECT KILLER—DDT.
(Courtesy of Geigy Company, Inc.)

Fig. 2. Dead Flies are Removed from a Small Test Box Which Had Been Sprayed 15 Minutes Previously with a DDT-Kerosene Solution.

(Courtesy of U. S. Dept. of Agriculture)

when the malaria-infected troops returned from the latter war, our native mosquitoes took advantage of the opportunity to spread malaria among the civilian population. And it is highly probable that malaria victims among the veterans of World War II have been the unwitting sources of recent localized malaria epidemics in the United States.

The name *malaria* is derived from two words: *mal,* meaning bad, and *air.* Thus the literal meaning of the word is *bad air.* Long before the role of the mosquito in the transmission of the disease had been discovered, men knew that in some way the air in the vicinity of swamps and other wet places was dangerous. They believed, of course, that evil spirits emanated from the swamps and entered their bodies, causing the chills and fevers, and weakness. This theory was almost correct. But unfortunately, no one realized that the evil spirits had wings and a death-dealing bite. Yet the idea of a relationship between swamps and malaria was quite correct, for water is essential for the breeding of mosquitoes—during the larval stage they are aquatic insects.

Since mosquitoes require water, we would except to find malaria along the shores of the oceans, in river valleys, around lakes and swamps, and in damp jungles—that is, unless the winters are too cold to permit mosquitoes to survive. Inhabitants of Asia—particularly of China and India—Mexico, Central America, South America, and the southeastern part of the United States have all had to learn to live with malaria. The use of screens on windows, the draining of swamps, the application of oil and insecticides to breeding places of mosquitoes have helped in some localities, but all of these efforts have been insignificant compared to the benefits conferred by a medicinal agent—quinine—extracted from the bark of the cinchona tree.

Whether cinchona bark was first used by the South American Indians or whether the Jesuits deserve credit for discovering its magical properties is of no importance. But since about the year 1630, the bark itself, or quinine, the active principal extracted from the bark, has alleviated the sufferings of untold millions. Today, when armies move into malaria-ridden districts, everyone is given his daily dose of quinine or the synthetic atebrin, and we all thrill to stories of jungle explorers calmly taking quinine pills while fighting wild animals and poisonous snakes. Quinine is not the perfect answer to malaria control. In fact, it is probably incorrect to say that quinine "cures" the disease. If one takes quinine regularly before he enters a malaria-infested district, and if he keeps up the treatment while he is there, the chances are that he will not get the disease—but he can't be sure, for some individuals become infected in spite of quinine prophylaxis. After one has contracted malaria, quinine treatment will lessen the severity of the disease, but it will not eradicate it.

The story of quinine is very much like that of rubber. For over two hundred years after cinchona bark was first used in the treatment of malaria, the world had to depend entirely for its supply on the wild trees of South America. Then the situation changed. Sir Clements Markham went to South America with an expedition in 1860 and procured over 400 cinchona plants and a number of seeds, with which he started plantations in India. And two years later a Dutch expedition under a botanist by the name of Hasskarl managed to get out of South America with about 500 cinchona plants and a number of seeds. Two plants survived the journey to Java where they were planted, along with the seeds, to start the cinchona industry in the Netherlands Indies.

The yield of quinine from the original plantings was very low, but in 1865 seeds of a high-yield variety were brought from South America by Charles Ledger, who turned them over to the Dutch when the British Government refused to accept them. With these seeds, the cinchona industry was established in Java on a large scale, and that country was supplying 95 percent of the world's quinine requirements when the Japs moved in, in 1942. The reason for the quinine shortage during World War II is, therefore, obvious.

Although malaria has been with the world for a few thousand years, it is more of a problem today than ever before. With airplanes covering thousands of miles in a comparatively few hours, malaria can easily spread to regions where it was formerly unknown. Infected mosquitoes can ride the airways and live to start an epidemic half way around the world from where they were born. Or, a person may pick up the infection in one country and not become sick until he is back home. All we can do is try to keep the mosquitoes under control. We can't hope to kill all the mosquitoes over millions of square miles of jungles, but we should do our best to keep down their numbers around our cities and towns.

Yellow Jack

In June, 1946, our newspapers carried notices of the death of a 68-year-old man. Ordinarily there is nothing unusual about this, for every time a prominent businessman, politician, or gangster dies, the newspapers dig into their morgues and do their best to find a few kind words to say about the deceased—and this is often a difficult task. But this man, whose passing did not go unnoticed, achieved fame by letting a few mosquitoes bite him. These were not ordinary mosquitoes: they were members of the species *Aedes aegypti,* and they had fed, shortly before, on the blood of yellow-fever victims.

This event occurred in 1900, when Major Walter Reed, of the Army Medical Service, was checking up on the idea that yellow fever was carried by mosquitoes. Major Reed asked for volunteers who would be willing to let mosquitoes bite them, and 26 soldiers and doctors were selected for the role of human "guinea pigs." Jesse Lazear died within a short time, others contracted the disease but had uneventful recoveries, and still others, like Pvt. John R. Kissinger, whose obituary we have referred to, lived on in pain and suffering for years. In 1906, the infection in his blood paralyzed Kissinger from the waist down, and thus he remained for 40 years. It is interesting to note that this man, who did so much for others, never looked upon himself as a hero. He refused all offers of money except the $125 a month disabled veteran's pension. How different his attitude was from that of some of the so-called "heroes" of the recent war, whose only combat experience was what they could purchase with a candy bar, and yet who feel that for their contributions to international relationships they should be supported by a grateful government for the rest of their lives.

Yellow fever probably originated in Africa, where there is a large endenic yellow-fever area extending 3,000 miles eastward from the west coast to the upper Nile. From here apparently it was carried to the New World on the slave ships along with their suffering human cargo. The Spanish colonies reported yellow fever as early as 1648, and in the years since then it has taken many lives in lands around the

Caribbean. In 1801, Napoleon sent General Leclere with 25,000 men to Haiti to put down the revolt of the negroes led by Toussaint l'Ouverture. The ill-equipped negroes were no match for the French troops and were easily defeated and driven into the interior. But then, yellow fever broke out, 22,000 Frenchmen died, and the 3,000 survivors evacuated the island in 1803. Thus, the Republic of Haiti was born, thanks to the mosquito!

The United States has not been free from yellow fever, although this disease, unlike malaria, has never become established here. Sailing ships from the West Indies often brought yellow fever into North American ports, particularly in colonial days. Cities as far north as Portland, Maine, have had yellow fever epidemics. In 1793, an epidemic killed 10 percent of the population of Philadelphia, and the disease returned six years later. A severe epidemic swept Memphis, Charleston, and Galveston in 1878, and in 1905 New Orleans felt the fury of a sudden attack.

During the Spanish-American War, our troops in Cuba encountered yellow fever as well as malaria, and at that time the cause of the disease was unknown. Because of the seriousness of the disease, something had to be done, and the Yellow Fever Commission was organized to track down the unknown killer. As was related previously, Walter Reed and his co-workers proved—but not until after the war was over—that the *Aedes aegypti* mosquito was the offender. This information came in very handy later when the Army engineers set to work to build a canal across the Isthmus of Panama. The French had made earlier attempts to build a canal there, but had to give up their efforts when yellow fever got in its deadly work. To the Americans, it was obvious that the first task was the elimination of the mosquito.

By draining swamps and covering other bodies of water with oil, this was accomplished, and the Panama Canal was built.

Yellow fever is by no means as widespread as malaria, and the yellow fever mosquito is much easier to control than his malaria-carrying relative. The first frost kills *Aedes aegypti;* therefore, the disease can only become established in climates where it is warm all-year round. The breeding habits of the insects also make control relatively easy. These mosquitoes are very sociable: they like to live near man. Instead of preferring to breed in out-of-the-way swamps or lakes, they breed in cisterns, water-barrels, flower vases, and other small bodies of water around the house or barn. Thus, just by seeing to it that there is no stagnant water—unless it is covered with oil—around the premises, we can eliminate this mosquito.

When a study of the breeding habits of the yellow fever mosquito showed that the insect could be readily controlled, many people began to envisage a yellow fever-free world. The success at Panama and the fact that yellow fever was eliminated from Cuba within a year after the discovery that the disease was transmitted by mosquitoes were certainly reasons for supporting this belief. And when yellow fever was eliminated from Rio de Janeiro and other places, everyone was convinced that with proper efforts success could be achieved within a very short time.

But dreams of a yellow fever-free world proved to be as futile as dreams of a world free from war. If every yellow fever mosquito within miles of human habitation were killed, if not a single human being on earth had the disease, it would still not be enough. The disease is not the exclusive property of man—it is shared by monkeys and possibly other animals. The jungles of the world act as huge reservoirs of the disease, and if at any time we relax our vigilance, Yellow Jack might slink out of the jungles and renew his deadly march.

Animals, Insects, and Man

Everyone with a dog, a cat, a flock of chickens, or a herd of cows knows that animals, as well as humans, get sick. But we are inclined to overlook the fact that animals may suffer from the same diseases that affect us. Since the infectious nature of disease was first established, we have often fallen into the trap of believing that we could always prevent the spread of a disease by keeping the sick out of contact with the well. But what good does that do if the disease is not spread by personal contact but by means of an insect? And worse yet, what if the insects don't carry the disease directly from person to person but, instead, transfer it from some animal to a human? Maybe your pet dog is carrying a disease that will some day be transferred to you. Don't say that's impossible because your dog is in the best of health. Remember Typhoid Mary and all the other typhoid carriers who show no symptoms of the disease yet can pass it on in deadly form to others.

Our knowledge of plague, typhus, malaria, and yellow fever should be enough to convince us beyond doubt that our animal population constitutes a reservoir of disease of appalling proportions. But that is only part of the story. How many other diseases come to us over the animal-insect-man bridge? That's hard to say! For some diseases, the chain of events has been proved; for others it is suspected; and for still others, although there is as yet no evidence of an animal origin, the possibility is by no means remote. How else can we account for the fact that some diseases flare up in different parts of the country at about the same time or within a very short time? To attribute this to human carriers doesn't seem logical, for often remote localities that haven't encountered an outsider in months are no safer than populous cities to which visitors come every day from all parts of the country. And why is it that many diseases flourish only in the summertime and subside with the return of cold weather? Logic tells us that the relationship between warm weather, insects, and certain diseases is more than a mere coincidence.

In the summer of 1946, a poliomyelitis epidemic swept the country—the worst epidemic since 1916. A disease of unknown origin was again on the rampage. Although the total number of deaths from polio is not large compared to the deaths from other diseases, the mysterious nature of this pestilence plus the fact that it leaves many of its victims cripples for the rest of their lives, make it probably the most dreaded disease in America today. In the case of polio it is difficult, indeed, to attribute the spread of the disease to direct transmission of the virus from one person to another. Since polio and flies flourish at the same time, many students of the disease have suspected that flies are the transmitting agents. There is no direct evidence of this as yet, but the virus of polio has been found in flies, and the disease has been transmitted from flies to experimental animals. But this still leaves the question of where the disease lurks during the winter months. Is it possible that animals, or perhaps birds, harbor the disease in an unrecognizable form, and that flies pick up the virus from the stools of these carriers and transport it to the food of prospective victims? Is the fly responsible for the spread of the various dysenteries that masquerade under the quaint name of "intestinal flu"? It's possible!

After all, the fly is known to transmit the disease of *pink eye* in cattle.

But let's look at a few diseases that are no longer in the realm of speculation. Rocky Mountain spotted fever is a disease very much like typhus. It attacks hunters, campers, and lumberjacks—people who go out into the woods and fields. The organism of this disease, like that of typhus, belongs to the *Rickettsiae* family. In fact, it was Ricketts himself who proved that the bite of the wood tick was the means by which men contracted the disease. But what animal was the reservoir of the disease? Ricketts' death at the age of 39 brought to an end his brilliant investigations, but many others took up the challenge, and during the past 40 years many thousands of wild animals have been examined in attempts to determine the culprit. One man who has trailed the elusive killer for the past 25 years is William L. Jellison of the U. S. Public Health Service. Jellison's investigations indicate that the probable host is a rabbit, Nuttall's cottontail and perhaps some related species.

But don't get the idea that spotted fever is limited to the Rocky Mountain region. This disease, or modified forms of it, has claimed victims in at least 41 of our states, and it has been spreading even to the cities. The summer of 1946 brought an attack of an eastern form of spotted fever to the Borough of Queens in New York, where, during a period of three months, 36 persons, ranging in age from three months to 72 years, contracted the disease. Undoubtedly, ticks spread the disease. But did the ticks get it from an innocent-looking cottontail, or did they pick it up from some other rodent, or perhaps a domesticated animal?

Worse than polio in its mortality is encephalitis—literally inflammation of the brain. This disease is world-wide in its spread. A severe epidemic broke out in Vienna in 1916, spread over Europe, reached Great Britain, hopped the ocean to North America, and appeared in about half of the states of the U. S. A. by May, 1920. Australia had epidemics in 1917-1918 and again in 1922 and 1926. In the summer of 1934, 60% of the over 7,000 victims in Japan died, and another epidemic broke out in Japan in the following year. The United States had a widespread epidemic in 1933, and has had a number of localized epidemics since. And the disease is not limited to man, for horses and sheep are also susceptible.

For many years, the mosquito has been suspected of being the transmitting agent, and this was recently proved by Doctors W. H. Hammon and W. C. Reeves of the Hooper Foundation for Medical Research, University of California. Of the many thousands of different kinds of insects that these men and their co-workers collected, only the mosquito was found guilty of carrying the virus. And even more startling was the proof that birds, both wild and domesticated, are the reservoirs of the disease. That is why most cases of encephalitis occur in rural areas, small towns, and suburbs of large cities—places where people keep chickens.

We could go on and on and show the possible animal-insect-man relationship in the transmission of many other diseases, but we shall bring this section to a close with a few words about African sleeping sickness. This disease is carried by the tsetse fly, and it affects animals as well as man. The only way to control the spread of the disease is to eliminate the flies, or at least to confine them to areas far from human habitation. That is why a news item from Pretoria, South Africa, dated July 21, 1946, is of particular interest. Briefly, this article stated that the biggest wild animal hunt in the history of Africa would begin the next day. All wild game—warthog, buffalo, and zebra—over an area of 400 square miles of Zululand were to be rounded up and transported to a specially prepared reserve. And a strip two miles wide was to be laid waste around the reserve, on the assumption that the tsetse cannot fly that distance. That is a drastic procedure!

But what are we in this country going to do? Will we be forced to exterminate the wild animals of our woods, or confine them in special reserves? Will the raising of chickens be restricted to certain regions of the country, and the area be placed under strict quarantine? Will it be considered a criminal offense to keep a dog or cat or perhaps a rabbit? Will horse racing finally be barred, not because of the evils of gambling, but because horses carry disease? There are legitimate arguments for doing all of these things. But wouldn't it be much simpler if we would just concentrate on getting rid of the insects that carry the diseases from animals to man? And remember this: don't be misled by the assumption that "it's just a harmless insect." How do you know it's harmless? Just because there is as yet no proof that a particular insect is harmful does not mean that it is harmless. When a man is brought into a court of law, we assume that he is innocent unless he is proved guilty. This is a sensible attitude for it does give greater protection to innocent people, even though, unfortunately, it also permits many of our gangsters and other public enemies to escape punishment for their crimes. But, be this as it may, when we deal with insects, the only wise thing to do is to assume that they are guilty unless they are proved innocent.

Chapter Two

DDT Is Born

Unwept, Unhonored, and Unsung

DESTINED to live a life of virtual obscurity and to die unaware that he held within his grasp the key to fame and fortune—that was the fate of Othmar Zeidler. For almost seventy years, while millions of people on the face of the earth died in agony from the bites of lice, flies, fleas, mosquitoes, and other insects, the chemical formula of a white, crystalline substance that could have saved these lives was available to anyone who had the curiosity to look for it. But no one bothered to thumb through the dusty volume of the *Berichte der Chemischen Gezellschaft*—The Proceedings of the German Chemical Society—for the year 1874, and to read the six obscure lines of type that described the preparation of dichloro-diphenyl-trichloroethane—DDT to you—by Othmar Zeidler, a young chemistry student at Strasbourg, Germany.

After all, Zeidler himself had little interest in what he had done. Like thousands of other chemistry students who have gone through the ordeal known as "working for a degree," Zeidler had to prepare a thesis, an uninspiring task at which a student slaves away in a routine manner until he accumulates enough data to "write-up" and submit to his professors, who, feeling that the poor student has been punished enough, then grant him his degree. It was in just this routine fashion that Zeidler reacted chloral hydrate—known in disreputable circles as knockout drops or Mickey Finn—and chlorobenzene, in the presence of sulfuric acid, and obtained the product he described. He had completed his task; he had added another organic compound to the rapidly growing list—a list that now comprises several hundred thousand compounds and is growing longer every day.

To Zeidler, his product was just like many others, except, of course, that the various atoms of carbon, hydrogen, and chlorine were hooked up in a somewhat different pattern than they were in any other compound. How could he know that his particular pattern of atoms carried potential death to many of man's most formidable enemies? Just think how the course of events might have been changed if, on that day in 1874, a fly buzzing around a laboratory in Strasbourg had decided to investigate the nice white precipitate that Zeidler had obtained! Suppose that a fly had lit on this first sample of DDT. Do you believe that Zeidler would have watched the curious creature stagger around like a drunken sailor and then drop dead? No, he would probably have been so outraged at the presumptuousness of an insect that dared to contaminate the product of his careful labors that he would have smacked the little fly dead before it had a chance to exhibit the symptoms of DDT poisoning. So let's not blame Zeidler for not discovering the magical powers of the substance he prepared. Undoubtedly, in other dusty volumes on the shelves of our libraries, there can be found the formulas of numerous other, and even more, magical substances—substances capable of curing the worst ills of man—with properties as yet unrecognized. Perhaps some day when the cure for cancer or tuberculosis is found, we may delve back through the years and find that long, long ago the self-same formula had been worked out by some other obscure chemistry student while working on his thesis.

The Lost is Found

Contrary to common opinion, great scientific discoveries are seldom the result of accident. Instead, they result from carefully planned programs of research in which a large number of scientists usually collaborate. DDT was no exception. Although Zeidler had prepared DDT many years ago, he was not looking for an insecticide and was in no position to recognize one when it suddenly appeared in his test tube. It remained for a large chemical company and teams of trained research scientists to give to the world this remarkable discovery.

In about the year 1934, in the scientific laboratories of J. R. Geigy, A. G., of Basle, Switzerland, a team of workers began a series of investigations aimed toward the development of more potent insecticides. They tested the effectiveness of a large number of available insecticides; they selected those that showed the greatest promise; and then they synthesized a large number of new materials in order to determine the effect of different arrangements of the atoms. Among these investigators was Dr. Paul Müller, and one of the products he synthesized proved to be of startling effectiveness. Unknown to Müller, this compound was identical with the white, crystalline substance prepared years before by Zeidler. Laboratory tests of this new insecticide against flies and the larvae of clothes moths showed that it had great potentialities, but many materials which survive laboratory tests reveal unexpected limitations when used on a large scale under actual field conditions.

But DDT did not have to wait long to prove its worth. In the year 1939, the potato crop of Switzerland was threatened with devastation by an unwanted immigrant from the United States—the Colorado potato beetle. Something had to be done in a hurry, and something was done! As a result of their experiments, Geigy felt that their new insecticide might be the answer, and they supplied Dr. R. Wiesmann, a Swiss entomologist, with a quantity of their "Experiment No. G 1750"—later called *Gesarol*. Wiesmann tried out this product—a 1% DDT dust—at the Swiss Federal Experimental Agricultural Station at Waederswill, where its remarkable insecticidal properties were verified. Then, out into the fields it went; the Swiss potato crop was saved; and the magic letters *DDT* were soon destined to become a common household expression throughout the world.

Soon the world was to be embroiled in a conflict of unimagined proportions. Man was destined to kill his fellow man on battlefields throughout the world. Many American boys, brought up in a country where the standards of sanitation are the highest in the world, were soon to be sent to many lands where the menace of typhus and other dreaded diseases awaited them. Medical men were well aware of the serious implications of the situation, and our medical resources were rapidly mustered to study means to save our military men from the fate that had befallen so many armies in the past. The experiments of Geigy in Switzerland had shown that DDT was an amazingly effective killer of the louse—that tiny insect that carries the dreaded typhus. In August 1942, Geigy informed Major De Jonge, American military attaché in Berne, Switzerland, of their amazing results, and at the same time it forwarded this information to its American subsidiary, Geigy Company, Inc., in New York. It would be nice at this point if we could repeat the highly dramatic but totally false story that appeared in some of our newspapers to the effect that a quantity of DDT was smuggled out of Switzerland in the best tradition of a wartime spy thriller. However, the prosaic truth is that the DDT was merely sent through regular channels from Geigy in Switzerland to Geigy in New York.

When Geigy in New York received this first shipment of DDT, it submitted samples to the U. S. Department of Agriculture for testing. The results were phenomenal, and another 200 pounds of DDT were imported from Switzerland and distributed to various Department of Agriculture Experimental Stations throughout the United States. From every source came startling confirmation of Geigy's claims.

Colonel William S. Stone of the Surgeon General's Office was quick to realize how important it was to our armed forces to have this miracle killer. At Orlando, Florida, 29 scientists, at the experiment station there, were assigned to devote their entire energies to the development of DDT compositions for military uses. To these 29 men—many of whom remain anonymous—many Italian citizens as well as American troops owe their lives. It is the common fate of technical men to go unrecognized for their efforts in behalf of humanity, but we can at least express our appreciation to three of the men, Dr. F. C. Bishop, Dr. Walter E. Dove and Mr. E. F. Knipling, who played such an important role in developing military uses for DDT.

The value of DDT to our armed forces was soon clearly demonstrated. Now it had to be turned out on a large scale. American industry accepted the challenge in the same spirit

FIG. 3. YOUNGSTERS ARE TREATED WITH DDT POWDER DURING THE ARMY MEDICAL SERVICE'S SUCCESSFUL CAMPAIGN TO STOP THE TYPHUS EPIDEMIC IN NAPLES IN EARLY 1944.
(Courtesy of Geigy Company, Inc.)

FIG. 4. CAPTAIN ARTHUR W. HILL OF WASHINGTON, D. C., AND T/5 JOSEPH RUSSOTTO OF BAYONNE, NEW JERSEY, APPLY LOUSE-KILLING DDT POWDER TO AN ARAB FAMILY AT L'ARBA IN ALGERIA.

(Courtesy of Prev. Med. Serv., Surgeon General's Office)

Fig. 5. Colonel W. S. Stone Dusts an Arab with DDT Louse Powder.
(Courtesy of Prev. Med. Serv., Surgeon General's Office)

FIG. 6. THIS SOLDIER WON'T BE BOTHERED BY LICE AFTER HIS DUSTING WITH DDT POWDER.
(Courtesy of Geigy Company, Inc.)

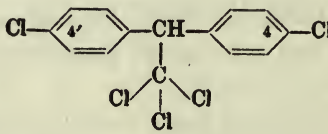
with which it had taken on so many other seemingly insurmountable problems during the war. In 1943, DDT was in commercial production at the Cincinnati Chemical Works, a subsidiary of Geigy Company, Inc., and early in 1944, Du Pont, Merck, and Hercules Powder Co. also went into production. In fact, within a short time, 15 American chemical companies were producing DDT for our armed forces; and another problem had been licked through American ingenuity.

Although there are a large number of manufacturers of DDT, the use of this substance in insecticidal preparations is covered by patents issued to Geigy in various countries, including Switzerland, England, Canada, and the United States. To make this magic insecticide available to everyone, Geigy has followed a very liberal licensing policy. Manufacturers of insecticide compositions containing DDT are licensed under the Geigy patents and pay a nominal fee for this right—a fee that is remarkably low when one considers the tremendous cost of the many years of development work by this company.

What Is DDT?

To the average individual, DDT is a material that is used to squirt the obnoxious fly and mosquito so as to shorten the days of their lives; or it is a powdery material dusted down the pants of a dirty individual in order to kill lice. Actually, to call either of these materials DDT is not strictly correct, for pure DDT is never used as such but is always compounded with other ingredients to form the various sprays or powders that are now being sold throughout the country. You won't find pure DDT in the corner store. If you want to see it, you must go to the factory where it is being manufactured or formulated.

But what is DDT? To you it is a killer of insect life. To the chemist, it is a compound of carbon, hydrogen, and chlorine, represented by the following structural formula,



and bearing the name dichloro-diphenyl-trichloroethane. It is easy to see from the jaw-breaking length of this chemical name that a drastic abbreviation was necessary. An official of the British Ministry of Supply got tired of writing this long chemical name, and early in 1943 earned the gratitude of many suffering stenographers by substituting the simple letters *DDT.* And DDT it has been ever since.

Pure DDT, as designated by the above formula, is a white, crystalline powder with a weak, fruit-like odor, and having a melting point of 107-108°C. The commercial product, however, melts as low as 88°C., due to the presence of so-called isomers, that is, compounds having the same number of carbon, hydrogen, and chlorine atoms as shown in the above formula but arranged in a slightly different manner. These isomers don't harm the product, for they also possess insecticidal properties.

If you should be interested in making some DDT, you could follow the instructions which appear in a 1942 British Patent issued to J. R. Geigy, A. G.:

"225 parts of chlorobenzene are mixed with 147 parts of chloral or the corresponding amount of chloral hydrate

> and then 1,000 parts of sulfuric acid monohydrate are added. Whilst stirring well, the temperature rises to 60°C. and then sinks slowly down to room temperature, the mass then containing solid parts. It is poured into a great deal of water, whereupon the product separates in solid form. It is well washed and crystallized from ethyl alcohol forming fine white crystals, having a weak fruit-like odour."

In 1945, almost 33 million pounds of DDT were produced in the United States, and for practically the entire output, batch processes similar to that described above were employed. Production was stepped up even higher in 1946, but the method of manufacture has remained virtually unchanged. To the chemical engineers in the industry, this has been rather disconcerting, for every time a chemical engineer encounters a batch process he gets an almost uncontrollable desire to replace it with a continuous process, and thus decrease the cost of manufacture. Engineers lost no time in applying their skills to DDT manufacture; and it was not long before continuous processes were announced. But, apparently, all the problems associated with continuous manufacture have not yet been solved; at least, no continuous process is, as yet, in commercial operation on a large scale.

DDT is insoluble in water, and this property has an important bearing on the way this insecticide has to be formulated. Since you can't dissolve DDT in water, you must dissolve it in some organic solvent in order to obtain a product that you can spray around the house. Numerous solvents can be used, but the most common—because of its low cost—is kerosene or some other petroleum distillate. Of course, for many applications it is not necessary to use DDT in solution form—it is often advantageous to apply it in the form of a powder. But even for application in this form, you couldn't use 100% DDT even if you wanted to. The crystals of DDT are very waxy, and this makes it impossible to grind them to a fine powder. However, if DDT is ground with pyrophyllite, talc, or some forms of clay, a finely-divided, uniform, and free-flowing powder results.

Free Enterprise

It was the summer of 1945, and the civilian population of the United States, having heard of the wonders of DDT on the battlefields of the earth, was waiting, almost breathlessly, to get some of this white magic to fight their own battles against the fly, the mosquito, and other insect pests. But the War Production Board said "No!" Although Germany had been defeated, there was still a war on with Japan; and the armed forces, of course, had the No. 1 priority on this wonder killer.

Manufacturers of DDT, according to the regulations of the W. P. B., could release only 5 per cent of their output for civilian purposes—the rest had to be reserved for the armed forces. In view of the unprecedented demand, 5 per cent was even less than the proverbial "drop in the bucket."

But the picture suddenly changed. A smart young chemist named Walter Steuber, of Swarthmore, Pennsylvania, decided to cash in on this ready market. Like other chemists, he knew the formula for DDT and how it could be made. Furthermore, he knew that the raw materials—chloral hydrate, monochlorobenzene, and sulfuric acid—could be obtained at that time without priorities at the corner drugstore. So he converted the cellar of his house into a miniature chemical plant, and started flooding the suburbs of Philadelphia with DDT solution at $1.00 per pint—paying no attention whatever to W. P. B.'s 5 per cent limitation. The public rushed to buy; and Mr. Steuber made a handsome profit.

The W. P. B., however, was mighty displeased with this flagrant flouting of its regulations, and the regular manufacturers of DDT, who had been anxiously awaiting the start of the race for the civilian market, were not happy to see a competitor—even though he operated on an insignificant scale—get the jump on them. It would have been easy to crack down on Mr. Steuber, but the W. P. B. decided, very sensibly, to permit all manufacturers to sell a much higher percentage of their output for civilian purposes. The battle for the domestic market was now on. Soon, DDT preparations, under numerous names and formulated by various companies, were appearing in store windows all over America.

Chapter Three

Not Too Hot to Handle

Did It Taste Good?

HE felt very nervous and sick at the stomach. Then he began to vomit. Something was wrong with his jaws: they were painful and felt stiff. The trouble seemed to start when he took that last chew of tobacco a few hours before. But how could that cause it? He had chewed tobacco for years—that same brand of plug—and had never noticed anything like it before. Perhaps his quid did taste slightly different than usual, but then, when you carry a plug of tobacco around in your pants pocket along with everything else you put in your pocket during the day, you can't expect it to taste the same every time you bite off a chunk. After all, a farm hand can't be too particular; he can't throw his plug of tobacco away just because it gets a little dirt on it.

But the doctor was curious; he had never before encountered this combination of symptoms. However, the sore jaws, the twitchings, the muscular tremors, and the nervousness had been observed by a number of investigators when they administered toxic doses of DDT to experimental animals. Had this man been using DDT? As a matter of fact he had carried around a bottle of a DDT-kerosene solution earlier in the day. And he had carried it in the same pocket where he kept his tobacco! Could the stopper have come loose and could some of the liquid have leaked out onto the tobacco? This was, at least, a possibility. Did he have DDT poisoning? Better check up! Sure enough, his urine showed DDT!

The farm hand soon felt better and was able to get back to work, although his throat felt sore for about three days. Whether or not he learned his lesson and took better care of his plug of tobacco in the future is not part of the record.

This enlightening experiment in the spring of 1946, although entirely unintentional, was certainly very valuable for it was the first authentic report of the toxicity of DDT on man. It was recorded for posterity in the Journal of the American Medical Association by Dr. M. I. Smith, of the National Institute of Health in Bethesda, Md.

From a purely scientific point of view, this experiment left much to be desired: there was no record of the amount of DDT that this lover of tobacco had consumed. Nevertheless, it must have been many times the amount that anyone would be likely to get accidentally under even the most careless conditions of use. Actually, among all the hundreds of workers engaged in making DDT, in formulating sprays and powders, and in testing the products over periods of months, no case of DDT poisoning has yet been reported. But, let's look into this matter of toxicity a little more thoroughly.

Don't Be Afraid!

Something that will kill bugs may also kill animals, even man. This sounds logical enough, but it isn't necessarily true. However, it's hard to convince some folks of that. And when DDT first hit the civilian market, many people were afraid to handle it. This, in part, was due to the fact that DDT was a relatively new material and neither the manufacturers themselves nor the governmental agencies that were working with it had had sufficient time to learn all about it. Of course, it was known that DDT was somewhat toxic to many of the lower animals, but experiments were still inconclusive. But what of its effect on man? Would a single large dose kill? Would a number of small doses taken at intervals over a period of time have a cumulative effect that would eventually result in death even though a single dose produced no toxic symptoms?

Obviously, few men are so constituted that they will act as human guinea pigs so that the world may get the answers to such important questions. A more indirect approach must be used. Rats, mice, rabbits, cats, dogs, and numerous other animals must take the place of man himself and be the unwilling test animals. The manufacturers as well as various governmental agencies lost no time in rounding up a number of these animals and forcing DDT down their throats, injecting it into their bodies, and applying it to their skins.

But all such tests take time, particularly if one is studying the cumulative effects of small doses of a substance taken at intervals. Should DDT have been kept off the market until years had elapsed and enough data had been collected to determine without doubt just exactly how poisonous it was? This would have been senseless, for in the meantime the insects would have been able to continue their deadly work. It was certainly much better to release the material to the public with a word of caution as to its possible dangers. Let people use it, but let them also realize that they should also use common sense in handling it. That was the attitude of the U. S. Department of Agriculture, Production and Marketing

Administration, Livestock Branch, which casts an eagle eye on the labels of all insecticides sold in interstate commerce to see to it that no false claims are made and to make certain that the purchaser is fully informed as to all safety precautions he must observe when handling the insecticide.

Avoid excessive inhalation of the spray or dust! Do not contaminate foodstuffs! If a solution of DDT is accidentally spilled on the skin, wash it off with soap and water! That is all that is demanded in the way of caution, except of course, the usual one in the case of inflammable liquids—avoid fire or open flame! There is nothing in these statements that should have frightened anyone. Of course you should avoid inhaling insect sprays: most of them contain petroleum solvents which themselves can make you slightly sick if you imbibe or inhale enough. For that matter, you shouldn't breathe any more gasoline fumes or the fumes of cleaning fluids than you can help. As for avoiding contamination of foodstuffs, that also makes sense. You try to keep dust and dirt from getting mixed up with the various ingredients you use in making a cake, so why shouldn't you also keep DDT out of your food? As for washing your hands when you spill some DDT solution on them, that is not as essential as you may have been led to believe, but nevertheless, it's always a good idea to keep your hands clean.

How Much is Fatal?

Since no one has ever died from DDT poisoning, it is difficult to say just what a toxic dose is. If we assume that dogs, cats, and other small animals react in the same way to DDT as does man, we can get some idea. At least we can find out enough to alleviate our fears. Let's start out with rats, who seem to resemble man rather closely in their reactions to various disease organisms and poisons. There is no point in reviewing the results of hundreds of experiments, but let's take a typical one. A number of rats were given a total of 1.2 grams of DDT in $\frac{1}{5}$ gram doses per day over a six-day period, and then were watched for six months to see if they would exhibit signs of poisoning. They did not! In all respects they appeared perfectly normal. Now, these rats weighed an average of 300 grams each, or $\frac{2}{3}$ pound. If a man could tolerate the same dosage in proportion to his weight, then a 150-pound man could take 120 grams, or more than $\frac{1}{4}$ pound, of DDT over a period of six days without any ill effects. Or, to put it another way, he could eat over $2\frac{1}{2}$ pounds of a 10% DDT dust.

Or do you resemble a mouse more closely than you do a rat? In that case, you will be more interested in the experiments on four white mice, each weighing 10 grams, which were fed 0.015 grams of DDT (0.003 grams per day for five days). Thirty days later they appeared quite normal. Again extrapolating to find out how a 150-pound man would fare, we find that he could take 102 grams, or slightly less than $\frac{1}{4}$ pound, over five days and remain perfectly healthy.

Since some folks are reputed to take after the cat, we shall see what they might expect. One cat was fed a total of 315 milligrams and another 480 milligrams in six different doses, without any sign of poisoning. The experimenters, however, neglected to report the weight of the cats. So we scouted the neighborhood and picked up a typical alley cat, and found that he weighed 10 pounds. Thus, 15 alley cats are equivalent in weight to a 150-pound man. If one cat can take 480 milligrams of DDT, a man should be able to take 15 times that much, or 7,200 milligrams (7.2 grams;

0.015 pound). Judging from the experiments above with rats and mice as the test animals, a man could safely eat a lot more DDT than this. Apparently the cats could have tolerated, without discomfort, many times the quantity of DDT they were given.

For the dog lover, we have the experiment in which two dogs were fed 5 grams of a 5% DDT mixture per day for each 5 to 6 kilograms of body weight over a period of 31 days, with no sign of poisoning to man's best friend. This quantity figures out to be about 3.1 grams of actual DDT per day for a 150-pound man, or about 100 grams—slightly less than ¼ pound—for the 31-day period.

The sheep-like individual can take heart in the tests carried out on one of the members of this gentle tribe at the University of Southern California. This placid creature was fed, along with his regular food, 2 grams of DDT per day for 11 days, 4 grams per day for the next 40 days, and then 8 grams per day for the next two weeks. He thrived on the diet!

The results of these and many other experiments show what? Simply this: The quantity of DDT required to kill a person, or even to make him sick, is very great. Although everyone should have sense enough not to use an insect spray where it might contaminate food, it is highly improbable that even the most careless person could possibly get enough DDT on his food to endanger his health. Certainly DDT is much less toxic to warm-blooded animals than are many of the common agricultural insecticides, such as the arsenicals, and lead and fluorine compounds.

Will DDT Poison Warm-Blooded Animals?

It would be a gross mistake to leave one with the impression that DDT is harmless to man and other animals. It will poison and eventually kill if a lot of it is eaten over a long period of time. For example, rats fed one part of DDT in 10,000 parts of foodstuffs began to have convulsions after two months, and died within a few days thereafter. Other rats and mice fed on diets containing 0.05% DDT showed definite signs of poisoning after long periods of time. And sheep put out to graze in a pasture treated 48 hours previously with 40 pounds per acre of 10% DDT dust showed neurological symptoms after about 3 days, although none died.

Mice, guinea pigs, dogs, cows, horses, and rabbits—in addition to rats and sheep—have been given sufficient DDT over periods long enough to kill them, or at least to make them sick. The different species of animals showed marked differences in their susceptibility among different individuals of the same species. The same is probably true with men, for one man's meat is often another man's poison. Some of the less reputable members of human society have been known, on occasion, to drink copious quantities of automobile antifreeze and other equally unattractive concoctions. Some of these individuals seem to thrive on such a liquid diet, while others with less rugged constitutions soon lose more than just a week-end.

In general, when an animal gets too much DDT he loses his appetite, his nervous system goes haywire, and he gets the tremors; and finally, if he has had a sufficiently large dose, he gets convulsions and dies. Autopsies usually reveal fatty degeneration of the liver and kidneys and changes in the nervous system, but with no apparent damage to the brain and spinal cord. But this requires a massive dose of from 150 to 750 milligrams of DDT per kilogram of body weight, depending upon the animal, and this is equivalent to about 10 to 50 grams (about $\frac{1}{3}$ to $1\frac{3}{4}$ oz.) for our 150-pound man.

Do You Inhale?

When you chase the pesky fly around with a squirt gun and finally let him have it, you can notice the mist that engulfs the hapless insect. If you watch closely, you can see some of the fine, misty particles taking their time in settling to the floor. If you happen to inhale while in the midst of these minute, settling droplets, it is inevitable that some of them will enter your nasal passages. Should you rush to the phone and call the doctor or just quietly lie down and wait for the end? Unless you're a hopeless neurotic, you'll just forget the whole thing and go about your business looking for more flies.

When DDT fly sprays first appeared on the market, some department stores were guilty of some very poor psychology. They not only offered a word of caution, but they practically scared the daylights out of their customers by warning them to put masks over their faces, to wear rubber gloves, and to say good-bye to all their friends and relatives before taking the innocent looking spray gun in their hands. Is it any wonder, then, that many timid souls shrank from the DDT mist as they would from the open sores of a leper? It is all right to be careful—and very wise—but why overdo it?

Sure, if you give an experimental animal enough DDT spray to inhale, he will show the same symptoms of DDT poisoning that he will if you shove enough down its throat. But how much is enough? Much more than you will ever inhale during your occasional attacks on the uninvited visitors to your home. Three dogs were made to breathe $\frac{1}{10}$

gram of DDT per kilogram of body weight per day over a period of 18 days, at the end of which time only one of the three animals showed signs of poisoning. At the same rate, our 150-pound man would have to inhale about 6.8 grams of DDT per day, or over ⅓ pint of a 5% DDT solution! About the only way he could possibly do this would be to squirt the spray right up his nose; and even then it would be a rather tedious job. If the solution contained only one per cent DDT, our mythical man would have to work much harder—he would have to inhale about a quart of the spray.

The rabbit is not a particularly robust beast, but it has been found that when he is exposed to a 1% DDT-kerosene spray for 48 minutes a day he is still in the best of health after 4 weeks. If 48 minutes a day won't bother a little rabbit even when you try to make him breathe the stuff, it is very unlikely that you will be affected by breathing a little DDT mist for a few minutes a day. No, not even if your spray contains 5% DDT instead of 1%!

Your Lily-White Skin

Your bones and flesh are enclosed, more or less tightly, in a tough, thick membrane which we call the skin. Your usual preoccupation with this portion of your anatomy is principally with such matters as whether it is clean or dirty, whether it is firm and taut or hangs in baggy folds beneath your jaw bone and under your eyes, or whether it is freckled, pimply, full of blackheads, or needs a shave. Yet your skin—even if it is the type that no one loves to touch—is a very complicated mechanism that has many things to do. It holds the rest of you together; on hot days it lowers your body temperature by discharging perspiration to the body surface where it can evaporate and thus absorb heat; on cold days it keeps your sweat glands closed but opens your oil glands so that they can secrete an oily substance which forms an insulating film over your goose pimples; and it forms a protecting barrier between your muscles and fat and the outside world that swarms with bacteria, fungi, and insects. If bacteria light on your unbroken skin they lead neither a merry life nor a long one. But just let them find an opening where the skin has been punctured by a bite, a cut, or a broken blister from your too-loose shoes, and then their ugly faces—if they have any—light up with smiles of triumph as they find an environment that is very conducive to bringing up a large family.

So the skin is porous! Your perspiration—or shall we just say *sweat?*—originates within the body and passes outward, evaporating on the surface of the body or being absorbed by your clothing; in either case, spoiling your most romantic moments as you wonder if you, too, have B. O. But don't take it too hard; maybe it is your healthy human smell that is responsible for your lover's passionate insistence, and not the few drops of essence of musk deer—at $40 per ounce—masquerading under a name which grandma sure would consider carnal.

Now don't get the idea that just because some substances can pass through the skin from the inside of the body outward that the reverse journey is as readily negotiated. You may kid yourself that you look years younger after you "feed" your skin by plastering on some of Lady X's perfumed axle grease, but even if the stuff was any good, the quantity that could possibly get through the very outer layers of your epidermis would be much too insignificant to convert you from an old hag—who wouldn't even be whistled at by a marine on a dark night—to a sweet young thing one jump ahead of the wolf pack. But before we leave the subject, just one more word—if you want to feed your skin, the only way to do it is by feeding the rest of your body, preferably by means of a thick steak, if you can get one.

Why, then, all the fear of dire results when DDT solutions are spilled on the skin? Can DDT penetrate the skin? And if so, how much? And what does it do when it does penetrate?

DDT Crashes the Barrier

If talcum powder passed through the skin and entered the body, much of the female population of the world would weigh a whole lot more than it does—unfortunately—at present. And the coal miner would have such a black interior that when he cut himself, a black, inky fluid would drip forth. No, dusts and powders cannot penetrate the skin! And DDT dusts and powders, or even pure DDT, are no exceptions. That is why DDT powders can be safely sprinkled inside one's underwear to disturb the life of the crawling louse. And that is why a bed sprayed with a solution of DDT to kill bedbugs is perfectly safe to sleep in after the solvent has evaporated, leaving the crystals of DDT behind.

Let us now turn to sprays consisting of DDT dispersed in water. Are they dangerous to the skin? Absolutely not! When you go swimming, you don't become water logged—because water doesn't penetrate the skin. And even if water did penetrate to some extent, water dispersions of DDT would present no hazard, for the water could not carry the DDT with it, since DDT does not dissolve in water and the size of the DDT particles in a water suspension is much too great to

Fig. 7. An Unsung Hero of the War—A Volunteer Lets Body Lice Feed on His Back in Experiments That Helped Government Agencies Develop DDT for Use Against the Typhus-Carrying Louse. The Lice, on Patches of Cloth, are Allowed to Feed on the Subject's Back and Are Then Removed.

(Courtesy of U. S. Dept. of Agriculture)

FIG. 8. THERE WON'T BE ANY FLIES IN THIS ROOM AFTER THE YOUNG LADY FINISHES SPRAYING.
(Courtesy of Hercules Powder Co.)

Fig. 9. A Wise Housewife Knows That Insects Like to Hide in Dark Places.
(Courtesy of Hercules Powder Co.)

FIG. 10. THERE WILL BE NO FLEAS IN THIS HOUSE AFTER THE FLOORS AND RUGS ARE SPRAYED WITH A 5% DDT-KEROSENE SOLUTION.
(Courtesy of U. S. Dept. of Agriculture. Photo by Madeleine Osborne)

permit their passage through the minute pores of the body's barrier.

But when we come to solutions of DDT in organic solvents, the picture is somewhat different, for there is at least a possibility that some organic solvents can diffuse through the skin. Solvents such as gasoline, kerosene, benzene, chloroform, and acetone are capable of dissolving oils and waxes. Because of this property, it is possible that they could gradually diffuse through the skin. Of course, if there is some DDT dissolved in the solvent, it would accompany the solvent on its journey.

But let's try to separate some of the fact from the fiction. To merely state that DDT dissolved in organic solvents can be absorbed by the skin, without giving some idea of how much can be absorbed and what effect it has on the body, simply scares people without doing them any good. As for the facts: It is possible to produce symptoms of DDT poisoning in experimental animals by treating their skins with solutions of DDT in organic solvents for sufficiently long periods of time. But, there is as yet no evidence that human beings have ever been poisoned in this manner.

Laboratory workers are curious individuals: they often get tired of working on little animals and, to break the monotony or to get an answer that their guinea pigs couldn't give, they try their concoctions on themselves. In the spirit of scientific curiosity, research men have soaked cotton wicks in concentrated DDT solutions and stuck them on their arms for twenty-four hours. The results: no irritation, burning, or toxic reactions. And even the authors of this book have kept their hands and arms to the elbows covered with a 5% DDT-kerosene solution for several hours and could notice no sign of irritation or toxicity. And when one considers that hundreds of men and women have been engaged for months in the preparation and testing of DDT sprays and none has suffered injury, one is led, inevitably, to the conclusion that the danger of poisoning from DDT solutions on the skin has been grossly exaggerated.

Although it is true that a few good experiments are more conclusive than lots of reasoning, let us look at the problem from a different point of view. Although animals differ in their susceptibility to DDT, all the evidence points to the fact that a dose of less than 1/10 gram of DDT per kilogram of body weight is absolutely harmless, and many animals continue to thrive when much higher doses than that are administered. Now, 1/10 gram per kilogram of weight means that our mythical 150-pound man could take at least 6.8 grams of DDT—and probably much more—in a single dose without harm. As we pointed out a little while ago, it takes more than a third of a pint of a 5% DDT solution to furnish that much DDT; and can you imagine a third of a pint of the liquid being absorbed by the skin? Even if you took a bath in the stuff—although we don't recommend it—it is highly unlikely that you would be in any danger.

The Poor Fish

Many of our otherwise sane citizens enjoy nothing more than getting up at the break of dawn on a cold spring morning and wading through the cold waters of some favorite stream in the hope of tricking an innocent trout into believing that a bundle of gaudy feathers is good to eat. Other members of the piscatorial tribe brave swarms of mosquitoes and black flies in their attempts—often futile—to hook a prize-winning trout or salmon. But whether your fisherman prefers trout or bass, or catfish, perch, or suckers, he takes his sport seriously and is much concerned about the finny population of our lakes and streams.

So, when water areas are sprayed to control the mosquito, or when forest areas are sprayed to control the numerous insect enemies of our forest trees, the fisherman is understandably concerned about the effect of DDT upon his favorite sport.

The toxicity of DDT to fish has not been studied as thoroughly as has been the toxicity toward warm-blooded animals, but experiments that have been carried out indicate that fish and cold-blooded animals, such as frogs, snakes, salamanders, and crayfish, are killed by quantities of DDT which wouldn't even make a warm-blooded animal sick.

From a practical point of view, this means that waters containing fish should not be treated with too high doses of DDT. One-half to one pound of DDT per acre of pond or stream will kill lots of fish, and will destroy an even higher percentage of the aquatic insects upon which the fish feed. Therefore, it is a good idea to keep DDT out of the home of the fish, except where it is applied for mosquito control and the concentration is kept very low.

It's a Bird!

Birds, unlike fish, can tolerate appreciable amounts of DDT without turning up their toes. In fact, birds react toward DDT in about the same manner as rats, rabbits, sheep, and dogs. A toxic dose of DDT is about the same per unit of weight for animals with feathers as it is for animals with fur.

When large forest areas were first treated with DDT for the control of such undesirable insect citizens as the spruce budworm, gypsy moth, hemlock looper, pine tip moth, spittle bug, pine sawfly, and white pine weevil, our nimble nimrods and girl-scout leaders joined their brother nature-lovers, the fishermen, in expressing fears that the lilting sound of the chickadee as well as the drumming of the partridge would be stilled forever. This fear, like many others relating to DDT, was entirely unfounded. Extensive tests in which forest areas were treated by airplane with as much as 5 pounds of DDT per acre revealed very few dead birds, although the bird population did show a marked reduction a few days after the treatment, presumably because the insects—food for the birds—had been killed off, and our feathered friends had to seek elsewhere for their daily bread. But insects soon moved in to repopulate the treated areas, and with them returned the birds.

But 5 pounds per acre is much more than is needed. When from ¼ to 1 pound of DDT per acre is used—and this is all that is needed to control the forest insect pests—many insects, particularly of the harmless or beneficial types, still remain alive, and the feathered and furry inhabitants of the woods are seemingly unaffected.

The Killer of Killers at Work

Insecticides are of three different types: respiratory poisons, stomach poisons, and contact poisons. The naphthalene used for moth balls is an example of the first type. Such poisons are very volatile, that is, they evaporate rapidly. This is a disadvantage, for it shortens the effective life of the product after it has been applied. Furthermore, in high concentrations the respiratory poisons repel insects and thus drive them away to carry out their depredations elsewhere. Thus, stomach and contact poisons are of greater importance than the other type.

Let's go out into the garden for a few minutes and watch the insects at work on the potato plants, the cucumbers, and the cabbage. If your garden is like the garden of most green-thumb enthusiasts, you will have no difficulty in finding portions of leaves, and even whole leaves, missing, where yesterday all were intact. Now step closer, but don't disturb the handsomely-striped little beggar who is unconcernedly going about his business. See how fast that hole in the leaf gets bigger as he works around the edge? A little arsenic would fix him. Let's dust a little or spray some over the leaves of our once lovely potato plants. Then, when he and his brothers and sisters take their next meal they will eat the arsenic along with the leaves and get a fatal stomachache.

But this black monster over here with the wide-spreading antennas would have to be handled in a different manner. Unlike his gaily-colored pal of the potato vines, he obtains his meal by the soda-straw technique. That long gadget on the front of him is a tube which he sticks right through the surface of the leaf in order to suck out the sap in the interior. A stomach poison would be no good against him for it would never reach his stomach. His feeding tube would merely penetrate the film of poison on the leaf as he searched for pay dirt lower down. In order to hasten the end of this guy—literally a little sucker—we must use either a respiratory poison or a contact poison. Let's try the latter—perhaps some rotenone. We'll spray some on the leaves, and as our black friend wanders around looking for a nice place to get a meal, his legs will pick up some of the poison and Mr. Bug will soon find his equilibrium seriously affected.

Thus, in order to fight the two kinds of insects, the eaters and the suckers, we need two kinds of poisons: stomach and contact poisons. But think how much simpler it would be if we could use one poison that killed both types of insects. And, we can! For DDT is both a stomach and a contact poison. Just think what that means? One substance that does the work of two! Truly remarkable, and just how remarkable is revealed by the fact that of over 3,000 synthetic insecticides tested by the U. S. Department of Agriculture, only two—DDT and sodium fluoride—were found to have this dual-action property.

DDT Jitters

Insects, like animals, are literally bundles of nerves. Since these nerves control all actions of the body, an injury to the nervous system can have very tragic consequences. Thousands of people will never walk again because their spinal cords were injured—a fact momentarily brought to the attention of the world as a result of General Patton's fatal accident.

Insects and animals given a toxic dose of DDT soon develop tremors and then violent spasms. Watch a fly that has come in contact with DDT? See how he flies around like mad for a little while, and then staggers around as though drunk before he finally turns over and calls it a day? It is easy to see that his nervous breakdown is the real thing, and not of the type that bored wives indulge in when they suspect that hubby is engaging in extra-curricular activities.

But how can dragging a foot or the tip of a wing through a little DDT bring about this desirable—from man's point of view—result? Look at a fly or mosquito and what do you see? A number of legs, a proboscis, and various tentacles, or sense organs. All of these members are provided with nerves. The feet are particularly important for they are the organs of taste. Having "tongues" in their feet is certainly very unfortunate for the insects, for tasting DDT is not to be recommended.

But to go on with the story: Our insect steps into some DDT; and then what happens? The poison dissolves in the nerve substance and gradually works its way up the leg to the vital nerve centers, causing a progressive case of jitters as it migrates. This process, however, takes time. Many people, misunderstanding the action of DDT, have been disappointed with the results that they obtained. They put some solution in a spray gun, tiptoe carefully up to a fly, and let him have it. And the fly, very perversely, flies away. Ten minutes later the fly is still around, somewhat unsteady perhaps, but still alive. So our big-game hunter, with a shrug of disgust, throws his spray gun away and cries out in a loud voice, "DDT is no good!" But the fly is doomed. And if our hunter watches long enough, he will see a final kick, a shudder, and then peace, as the fly stretches out on his back, with his legs motionless in the air.

A contact poison does not work instantaneously—you must give it time. We can show that easily. Let's take two flies and put some DDT on one foot of each. A few minutes later let's cut off the treated leg of one of the flies, leaving the other fly intact. The amputated leg will show pronounced tremors and violent spasms for quite some time; but the fly who lost his leg will live. This shows conclusively that it takes an appreciable time for the poison to travel up the leg, and if the leg is severed before the poison has reached the insect's body, the fly will live. Of course, the other fly who does not undergo the amputation will soon join his ancestors.

It has been mentioned previously that single doses of $\frac{1}{10}$ gram of DDT per kilogram of body weight are harmless. To produce symptoms of heavy poisoning or death requires a minimum of from 0.15 to 2 grams per kilogram, depending upon the individual as well as on the species. These figures, however, refer only to warm-blooded animals. Per kilogram of weight, it takes only from 0.0006 to 0.002 grams of DDT to kill an insect. And since it takes thousands of flies to equal a kilogram of weight, the amount of DDT necessary to kill a single fly must be considerably less than a billioneth of a gram. And that is why DDT is such a good residual insecticide.

Flies can pick up fatal doses by walking over surfaces covered with an almost unbelievably thin film of DDT. In an experiment carried out by Geigy, a box made of wooden frames and glass panels was sprayed with a $\frac{1}{10}$% solution of DDT in acetone, and after the solvent had evaporated, each pane of glass was wiped 200 times with a woolen cloth. Flies were then introduced into the box, and they picked up enough DDT by walking over the polished glass to kill them within a few hours. Obviously, when residual sprays are applied to wooden or plastered walls, much greater amounts must be used because a lot of the material penetrates into the pores and does not remain on the surface where insects can get in touch with it.

Chapter Four

DDT Formulations

From Laboratory to You

ACCORDING to the old words of wisdom, everybody talks about the weather but nobody does anything about it. Likewise, everybody talks about DDT but few know what they are talking about. They spray with DDT and they sprinkle DDT powder around, without realizing the fact—which they could readily determine by reading the label—that their sprays or powders are formulations of which DDT is only one of the ingredients, and a minor one at that in terms of weight percentage. Pure DDT is never used as an insecticide: it is always incorporated with other substances, either active or inert, in order to give the best product for the particular job. And if you use the wrong formulation for your particular job, don't blame the DDT if you don't get satisfactory results.

It is true that when DDT formulations were first dropped into the outstretched arms of a waiting public, some unscrupulous companies, taking advantage of the tremendous publicity that DDT had received, duped the citizens by putting out products with insufficient DDT to do the jobs claimed. But the U. S. Government as well as the various states have names for such operators and have clamped down on their activities. Since all insecticides sold must bear labels approved by the U. S. Department of Agriculture or the Agricultural Departments of the states, one can feel certain today that the claims for a particular product are honest ones. Therefore, the best advice is: read the label before you buy, and read it carefully, fine type and all.

Shop around in your favorite stores and see how many different types of DDT formulations you can find. If you study carefully, you will find that they fall into the following classifications: (1) *Household sprays,* which are solutions of DDT and perhaps other insect killers in petroleum solvents, usually deodorized kerosene. These are of two types: residual sprays, with DDT contents of 5 or 6%; and space sprays, containing about ¼ to 1% DDT. These are the common sprays used against the fly, mosquito, and other pests that like to share man's abode. (2) *Aerosols.* These are little metal bombs, usually containing 3% DDT and 2% pyrethrum extract dissolved in a very volatile solvent. When the valve of the bomb is opened, an extremely fine spray mist shoots out and kills all insects—principally flies and mosquitoes—that it hits. (3) *Household powders,* usually made up of 10% DDT and the rest talc, pyrophyllite, or some other inert extender. These powders, which are so effective against bedbugs, fleas, ants, and other crawling insects, may also contain pyrethrum or other lethal agents. (4) *Emulsifiable solutions.* These are concentrated solutions of 25 or 30% DDT in organic solvents and dispersing agents. For use, they are mixed with water to prepare emulsions, of about 2½ or 5% DDT, for the control of flies and other insects in barns, poultry houses, and other outbuildings, and on cattle, horses, and other farm animals. They are also used for the control of various insect pests on agricultural crops, forest and shade trees, and other vegetation. (5) *Wettable powders,* containing up to 50% DDT and the rest inert ingredients, used as dispersions in water for the same purposes as DDT emulsions. (6) *Agricultural dusts,* containing usually from 1 to 5% DDT, for direct application to field crops for the control of various insect pests. (7) *Paints,* usually with about 5 or 6% DDT incorporated in a synthetic-resin binder, principally for interior purposes where residual insect-killing powder is desired.

Sprays and Sprays

When the housewife goes into a store and asks for some DDT, the clerk hands her a bottle of stuff with the letters *DDT* in large type. The DDT content may be 5% or less, so the good woman should stop a moment and think before saying those words that every clerk likes to hear: "I'll take it. How much is it?" If she wants something that she can apply to the walls of the dining room so that the flies that light there over the next six months will die, she had better make sure that it says 5% in front of the letters *DDT.* But if she merely wants to kill the flies that happen to be around at the moment she sprays, she will find that a considerably lower concentration of DDT will do the trick.

You see, fly sprays are of two types: space sprays and residual sprays. Space sprays have been in use for many years, and those exciting words, "Quick, Henry, the Flit," have been heard from one end of the land to the other—much to the profit of the manufacturer. When using a space spray you merely aim your gun in the general direction of the insects and hope that some of the misty particles hit each pest. Any insect who escapes the spray is safe, at least until the next time you let go with your ammunition. The older space sprays were prepared by making a kerosene solution of pyrethrum or an organic thiocyanate. Pyrethrum is a naturally-occurring poison found in the blossoms of a daisy-like plant grown in British East Africa, Belgian Congo, Japan, and Brazil. The thiocyanates are synthetic chemicals sold under the trade names of *Lethane* and *Thanite.* Pyrethrum is rather unstable: when exposed to light or to the air it soon decomposes. Thus, it has no lasting action. Pyrethrum, however, is a good killer, and because it is practically odorless, it is much in demand for fly sprays.

The thiocyanates are also effective killers, but they must be used in much higher concentrations than pyrethrum. During the war when pyrethrum became scarce, practically all household insect sprays were made with these synthetics. The thiocyanates are more stable to light and oxidation than is pyrethrum, but even they have no residual action. In other words, a wall sprayed with a thiocyanate solution would not continue to kill insects. One disadvantage of the thiocyanates is that they have an unpleasant and persistent odor which lingers on for a long time in an area where the spray has been used.

Both pyrethrum and the thiocyanates, in addition to being good killers, have rapid knockdown properties. This is important. When you use a space spray you want to get rid of the insects in a hurry. It is no consolation to know that they will be dead in a few hours. You want to keep them out of your soup now. That's where rapid knockdown comes in. The insects drop to the floor within a few minutes, although they may continue to live for another hour or so.

Grade AA

Perhaps you've noticed on your bottle of insect spray the statement that it is a *Grade AA* insecticide. You probably didn't give it another thought, resting content with a feeling of security that anything marked AA must be tops. Would you like to know a little more about the meaning of these letters? Well, here goes!

When you go into a store to buy a bottle of insecticide, you can't tell by feeling, tasting, or smelling the contents of the beautifully-colored containers which one is good or which one is bad, or how much better one is than another. Of course, this is true of most things you buy. But after you buy something and try it out, you soon find out whether or not you were a sucker for making the purchase. And if you come to the conclusion that you didn't get your money's worth, you certainly won't buy that particular brand of article again. Manufacturers know this as well as consumers. They know that to keep your business they must give honest value and make no false claims. Perhaps this is the best type of control for industry—control based only on the seller-purchaser relationship, without Government interference. Anyway, that's what lots of people believe, although lots of others take the attitude that the public can't manage its own affairs and has to have the Government act as its guardian. For further light on this interesting subject, read again the voluminous arguments, pro and con, over O.P.A.

Without delving further into the philosophy of price and quality regulation, we will merely state that insecticide manufacturers felt, for a long time, that it would be a good idea for the industry to voluntarily agree on certain standards of performance for household insecticides of the space-spray type. With standards of performance set up, the various manufacturers would have a common basis for comparing the qualities of their different products, and each manufacturer who desired could then indicate on his labels how his insecticide stacked up with the others.

On September 20, 1937, the National Association of Insecticide and Disinfectant Manufacturers, Inc. proposed the establishment of a commercial standard for household insecticides of the liquid-spray type; and the standard was later accepted and approved for promulgation by the U. S. Department of Commerce, through the National Bureau of Standards. This standard—known as Commercial Standard CS72-38—became effective on June 10, 1938. If you are interested, the Superintendent of Documents, Washington, D. C., will sell you a copy for 5 cents.

An insecticide that meets the requirements of the standard must be harmless to man and warm-blooded household animals when used as directed; it must not stain household furnishings, wall paper, etc.; it must not corrode metals; and it must have no objectionable odor. But the most important of the specifications deals with performance. And the only way you can tell what an insecticide will do is to try it out on insects.

For determining the killing power of a liquid insecticide, the *Peet-Grady* method has been accepted as the standard. In this method, approximately 100 houseflies, not less than 3 nor more than 5 days old, are placed inside of a test chamber, which is a 6-foot cube, constructed of wood or metal, and lined so that the inner surface is smooth, relatively nonporous, and free of cracks, projections, etc. The chamber is provided with a large, tight-fitting door, windows for observation and lighting, and various openings for admitting insects and insecticide, and for ventilation after the test.

After the flies are in place, 12 milliliters (about ⅖ oz.) of the insecticide are injected into the chamber with a special-type atomizer. Ten minutes later, the ventilating fan is turned on, the door is then opened, and the number of flies clinging to the ceiling and walls, together with any that are still flying, are counted. These are considered to be unaffected by the insecticide. The flies which have fallen to the floor are transferred to observation cages and are examined at the end of 24 hours to determine the number which are dead. Any flies that have revived during this period are also considered as unaffected by the insecticide. The percentage of the original flies which are found dead at the end of 24 hours is known as the *percentage kill.*

Each time an insecticide is tested, duplicate runs are made—one with the insecticide being tested and the other with the official test insecticide of the National Association of Insecticide and Disinfectant Manufacturers, Inc. If the insecticide being tested has a "kill" of from 5% less to 5% more than that of the official test insecticide, it is given the designation *Grade B.* If its "kill" is from 6 to 15% greater, it is classified as *Grade A.* And if its "kill" is 16% or more above that of the standard, it carries the highest rating of all—*Grade AA.*

Now you know what the words Grade AA on an insecticide label mean. But, you won't find the letters *AA, A,* or even *B* on all household sprays. This does not necessarily mean that the insecticide is of poor quality, for you must remember that acceptance of Commercial Standard CS72-38 is not compulsory, and some manufacturers just haven't bothered with it. However, most insecticide manufacturers and distributors have agreed to accept this standard, and it probably won't be very long before every bottle of household space spray you buy will bear the sign of distinction—Grade AA.

100% Active

The bottle of insect spray that you buy probably also carries the words: *100% Active Ingredients.* Since the major part of the material in the bottle is kerosene, this can only mean that kerosene itself is an insect killer. That is correct! Petroleum solvents—gasoline, kerosene, naphtha, fuel oil, etc.—as well as lots of other organic solvents do have lethal properties as far as insects are concerned. When your suit comes back from the dry cleaner, it is free from moth larvae, for they cannot survive their naphtha bath. Obviously, kerosene in itself is not sufficiently satisfactory for use alone as a fly spray, for if it were no one would bother to put in some pyrethrum, thiocyanates, or DDT. Nevertheless, the kerosene does contribute to the killing power of the mixture.

Oil to You

Kerosene, or as some people erroneously call it, coal oil, is probably known to you as the material that was used to furnish the light of the world in the days before Thomas Edison found out that a piece of charred cotton inside of an evacuated glass bulb could transform electricity into light. Yet, even today the kerosene lamp is a familiar sight in many places where the electric wires have yet to reach. Technically, kerosene is just a petroleum fraction that boils over the temperature range of about 400 to 500°F.

FIG. 11. GARBAGE CANS SPRAYED INSIDE AND OUTSIDE WITH 5% DDT WILL NOT BE BREEDING GROUNDS FOR FLIES.
(Courtesy of Hercules Powder Co.)

FIG. 12. A FLICK OF THE VALVE AND THE DEATH-DEALING DDT MIST FROM THIS AEROSOL BOMB WILL SPELL THE DOOM OF EVERY INSECT FLYING OR HIDING IN THIS ROOM.

(Courtesy of Hercules Powder Co.)

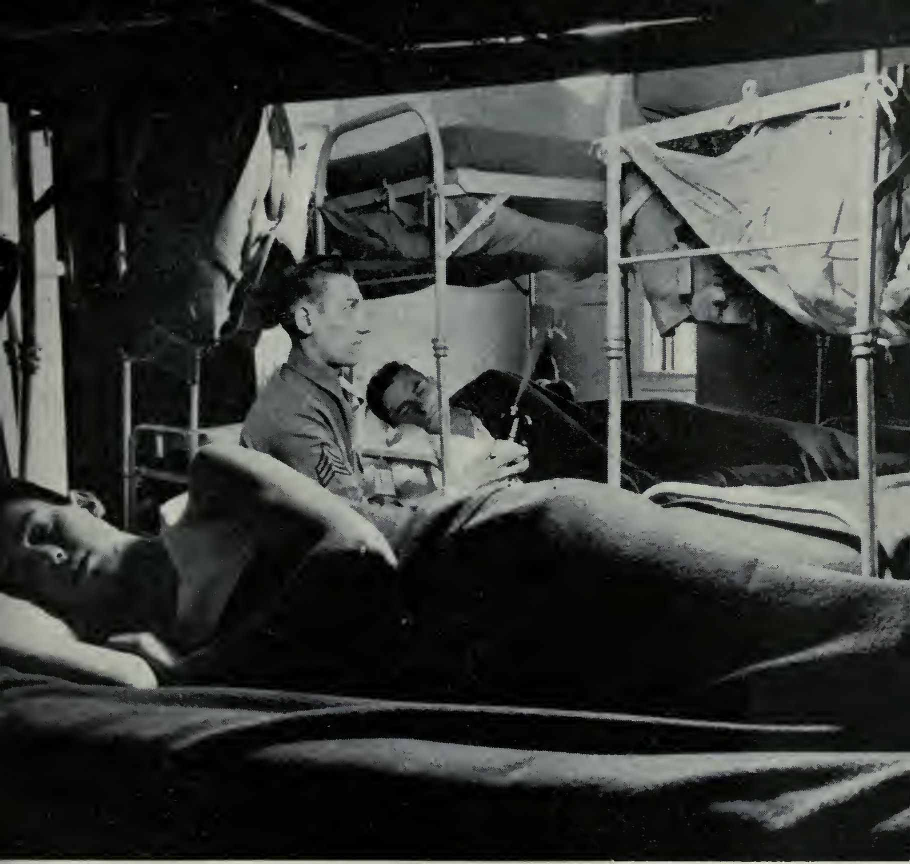


FIG. 13. SERGEANT EDWARD J. HALADAY RELEASES AN AEROSOL MIST TO KILL ANY INSECTS THAT ARE LURKING IN THE BARRACKS WHERE HIS COMPANY SLEEPS.
(Courtesy of U. S. Dept. of Agriculture. Photo by Knell)

FIG. 14. NURSE WILLIS CRAFT SPRAYS A BED AT THE ARLINGTON, VA. COUNTY HOSPITAL WITH 5% DDT TO ELIMINATE THE BEDBUG PROBLEM.
(Courtesy of U. S. Dept. of Agriculture. Photo by Madeleine Osborne)

Kerosene is a good material for household insecticides because it doesn't evaporate too rapidly, and thus carries the poisons where they will do the most good. In addition, there is much less fire hazard with kerosene than there would be with the much-more-volatile gasoline, although you must keep kerosene away from open flames, as many people have found out to their sorrow when they poured some kerosene into the old wood stove, not noticing that there was still some fire or hot coals present.

The ordinary kerosene or No. 2 fuel oil that your dealer can supply you with is perfectly all right for making an insect spray, particularly for use in barns and chicken coops, but its irritating odor is rather objectionable around the house. For that reason, most household insecticides are made with kerosene that has been treated to remove the odoriferous constituents. Incidentally, deodorizing is apparently an expensive process; at least the deodorized product costs about three times as much as the product you burn in your lantern. To top it all off, manufacturers, to cover up the odors of their insecticides, add small amounts of perfumes to "make it stink pretty."

Why DDT in Space Sprays?

In spite of the fact that pyrethrum and the thiocyanates are rather good insect killers, they can't compare with DDT. A 1/10% solution of DDT will kill a higher percentage of insects than will much higher quantities of these other killers, and at a much lower cost. But DDT, in spite of its marvelous killing powers, is slow acting: it does not have the desirable high knockdown characteristics of the other insecticides. Therefore, a kerosene solution of DDT alone does not make a good space spray: it will kill all the insects at your party, but not until after the guests have gone home.

The logical answer? Use enough DDT to give practically 100% kill. This does not require a high concentration—perhaps ¼ to 1%. And then add enough pyrethrum or one of the thiocyanates to give practically 100% knockdown. Since you are not depending upon these latter materials for kill but only for knockdown, you need much smaller concentrations than you would if you had to depend upon these agents for both knockdown and kill.

The Killing Mist

During the war, about sixteen million little bombs were distributed to our fighting men. These bombs contained no high explosive, but they spelled death to many a lurking enemy—*Anopheles,* the malaria-bearing mosquito.

On every Pacific island that formed a stepping stone to Japan, our soldiers, sailors, and marines found that mosquitoes swarmed in the jungles. It wasn't so bad during the day, for mosquitoes shun the sun. But at night, when all was dark and still, they searched out the sleeping forms of men and had their midnight snacks. Mosquito netting on barracks windows and across the end of tents kept out the tiny marauders at night. But what about the mosquitoes that managed to get in during the day and went into hiding, waiting until it got dark and the men were asleep so that they could slip out and attack without interference?

That's where these little bombs—the aerosol bombs—came in so handy. A flick of the valve, and within a few seconds the room or tent was filled with a mist of DDT and pyrethrum; and the mosquitoes dropped dead in mid air, or if they happened to be hiding at the time, the mist floated in on them and spoiled their plans for an evening meal.

Some years ago the late Thomas Midgley, of General Motors Corp., developed a new refrigerant for use in domestic and commercial refrigerators and in air-conditioning units. This substance—dichlorodifluoromethane—known as *Freon-12,* is a non-toxic gas at ordinary temperatures. To liquefy it at atmospheric pressure, you must cool it to about 22 deg. F. below zero. To liquefy it at room temperature, you must put it under considerable pressure. To make an aerosol bomb, all you have to do is dissolve 3% DDT and 2% pyrethrum extract in Freon-12 under pressure and charge the mixture into a metal container which is strong enough to withstand the pressure. When the valve is opened, the mixture under pressure rushes out at high velocity through a very small opening. This breaks the stream up into an exceedingly fine mist—the particles of which are very much smaller than the particles from an ordinary spray gun. Furthermore, with the release of the pressure, the solvent evaporates almost instantaneously, leaving the minute particles of DDT and pyrethrum suspended in the air. Because they are so fine, these particles do not readily settle out of the air; instead, they are carried around by the air currents, reaching practically all parts of the room.

Although developed primarily for killing mosquitoes in army and navy barracks and tents, the aerosol bomb is equally effective on other household insects, such as flies, sandflies, and moths in the flying stage. Their convenience of use and the rapid effectiveness of aerosols as space sprays led to considerable civilian demand for the bombs, and it was an easy matter for the manufacturers to turn from wartime to peacetime production.

Aerosols are the most expensive of the DDT formulations, but since only a small amount is needed to free a room of insects—a 1-pound bomb is enough for about 25,000 cubic feet of room space—the actual cost for treating the rooms of a house is not excessive.

It is interesting to note that Dr. Midgley, who unintentionally made an important contribution to the field of insecticides, was himself a victim of poliomyelitis—a disease he may have contracted through the medium of a fly.

Long-Lived Action

Without belittling the ordinary space spray or the aerosol bomb, we must admit that the one thing about DDT that attracted and held the attention of everyone was the fact that, when properly prepared and applied, a single application of a DDT formulation continues to kill insects for weeks, and even months. This is a unique property not possessed by any other insecticide for household use. Whenever one thought of DDT, he did so in terms of this residual action. As just another ingredient of a space spray, DDT was of little interest, for the sprays that one had been used to buying did a fairly good job. Yet, many of the insect sprays that were first sold to the public during the latter part of 1945 did not have residual action, for the quantity of DDT was too small.

To be a residual spray, the solution should contain at least 5% DDT. And it should be applied at the rate of about one quart for each 250 sq. ft. of surface, if long-lasting killing is desired with a single application.

This does not mean that solutions with less than 5% DDT have no residual action. They do! But remember that you can only spray so much liquid on the wall without having it run. If your spray solution contains less than 5 % DDT, the deposit left after evaporation of the solvent will be correspondingly thinner. Of course, you can re-spray a given surface a number of times, permitting the solvent to evaporate between sprayings. In this way you can build up a good deposit of DDT on the surface. But, five sprayings with a 1 % DDT solution have proved less effective than a single application of a 5 % spray. And anyway, why make a lot of extra work for yourself by using a 1 or 2 % DDT spray when a 5 % spray will do the job with one application.

But just because you buy a 5 % DDT spray don't get the idea that your problems are over. It is up to you to see that it is properly applied. Too many people put the stuff in their spray guns, take three squirts at the wall, and expect their house to be free from insects all summer. And when they find the insect population thriving, they blame the DDT and not themselves.

You see, a residual spray works like this: You spray the walls, lamp cords, screen door, and other places where insects light, and when the solvent evaporates the DDT crystallizes out and remains on the surface. When a fly or a mosquito rests on or walks across such a treated surface, he picks up some DDT and dies, usually in one to three hours, with tremors and spasms.

Residual sprays do not need knockdown agents, although it would be nice if something could be added along with the DDT so that the insects dropped dead as soon as they hit the wall. Pyrethrum and the thiocyanates are not of much help because they do not remain effective for very long. Nevertheless, many residual sprays now contain pyrethrum or thiocyanates—about 1 % of pyrethrum extract or 2 to 3 % of the thiocyanates. This is a good idea, for then the spray, in addition to being a residual spray, can also be used as a rapid-knockdown, high-kill space spray. Thus, a single spray can take the place of two.

Although residual sprays are most commonly used for controlling flies and other insects on the walls of homes and barns, they are also very effective against bedbugs and clothes moths. Three fluid ounces of a 5% DDT-kerosene mixture properly applied to a full-sized bed will keep it free from bedbugs for six months. Operators of hotels and rooming houses will appreciate the value of this. They also know that a bedbug spray should be as free from residual odor as possible so as not to advertise to the guest that the bed he is to occupy was once the dwelling place of repulsive little creatures.

The 5% DDT-kerosene solution is also a good mothicide. But because kerosene takes a rather long time to evaporate, there is some advantage in using the much-more-volatile naphtha in place of kerosene. The fire hazard is somewhat greater with naphtha solutions, but one should have no difficulty if he follows the same rules of caution that he does when treating his clothes with cleaner's naphtha. Incidentally, if your good wool suit is treated with DDT, it will remain free from moths for at least several months, unless the deposit is removed by dry cleaning.

Powdered Death

Does your dog have fleas? Or do you have lice in your pants? Don't use the spray gun! The spray would kill these insects all right, but there is a possibility that some of the poison might be absorbed through your dog's hide or your tender skin. Take a powder—literally—a DDT powder, and sprinkle it in your pooch's fur or in your underwear. A 10% DDT powder is what you want—the same material that proved so effective in stopping the typhus epidemic in Naples.

These powders are made by grinding DDT with an inert ingredient, usually pyrophyllite or talc. The powder flows easily and adheres well. Like the residue left from a 5% DDT spray, the powder has residual action, retaining its effectiveness for months.

About 1½ oz. of the powder sprinkled around on the mattress, springs, and joints of a full-sized bed will keep it free from man's nocturnal companions—the bedbugs—for at least six months. Sprinkled around the hiding places of cockroaches, the powder will eventually rid the premises of these pests, although it takes about a week before you can see the results. Similarly with ants: sprinkle the cupboard, baseboards, under the sink, and other places where these little insects migrate. Of course, be sure you don't get the powder on food, for you want to kill the insects, not yourself. But don't worry about getting it on your skin. It won't hurt you. And it won't hurt your dog to have a good deposit of DDT on his hide either. But don't use it on your cat, for he—or is it a she?—likes to lick himself to keep his fur nice and clean. Licking up some DDT probably wouldn't kill him but it might make him sick. However, you can control his fleas by sprinkling the powder around the place where he sleeps.

Milky White

It is unfortunate that DDT is not soluble in water. If it were, it would be much easier to use for many purposes.

But, no use speculating upon something that can't be. If we can't dissolve it in water, we can at least disperse it in water, and that is some help. We can make two types of dispersions: We can mix up a dry DDT powder with water, or we can dissolve the DDT in some organic solvent to make a concentrated, 25 or 30% solution, and then we can mix the solution with water. We'll talk about the first type of dispersion, known as a *suspension,* in a few minutes. But first, let's take up the second type, known as an *emulsion.* This is a dispersion of one liquid in another.

An emulsion has two phases: a dispersed phase (in this case, a solution of DDT in a solvent) and the dispersion medium (in this case, water). We can't use kerosene or fuel oil as the solvent for DDT in the preparation of emulsions because the DDT is not soluble enough in these solvents. To get 25 or 30% DDT in solution, a material like xylene, a coal-tar hydrocarbon, must be used. Furthermore, we must use a third substance, known as an emulsifying agent, in order to give a product which is relatively stable. You know the old saying that "oil and water don't mix." This is not strictly correct. It is true that oil will not dissolve in water, but under the proper conditions you can get a mixture that is so uniform that it looks like a single substance. You can try this yourself: Shake up some water and kerosene together. See how milky it looks? But now let it stand without shaking. Notice how the little particles of kerosene coalesce and rise to the top? All you have left is a layer of kerosene on top of a layer of water.

Now add a little soap and shake up the water and kerosene again. See how much longer it takes for the kerosene to separate out? The soap is the emulsifying agent. Once upon a time soap was about the only emulsifying agent we had, but today there are a wide variety of synthetic substances that are much more effective than soap. These materials come on the market under a variety of trade names, a few of which are *Emulphor, Chovis, Mulag, Tween,* and *Tegin.*

The quantity of emulsifying agent needed is not very great. For example, a good 30% DDT concentrate for emulsion purposes can be made by dissolving 30 parts by weight of DDT and 4 parts of an emulsifying agent in 66 parts of xylene.

Since these concentrates are made with organic solvents such as xylene, they are inflammable, just like the ordinary 5% DDT-kerosene solution. Furthermore, the concentrate must never be used as such on animals or plants. Not only is the DDT concentration too great for direct use, but the solvent itself might cause damage.

To make a 5% DDT emulsion from a 30% concentrate, you simply stir one part of the concentrate into 5 parts of water. Because of the large amount of water in proportion to solvent, the emulsion is nonflammable. Thus, it makes a nice product to apply to the walls of barns and other buildings as a residual spray for the control of flies. However, it should not be used in homes because the water would streak and stain your pretty wall paper.

Also, because of the low concentration of solvent in the finished emulsion, emulsion sprays can be used on animals as well as on plants. But for use on plants, you will want to dilute the concentrate to make a spray with only about ½ or 1% DDT. So follow the directions on the bottle before going after the bugs.

Powders That Wet

Well, if you can dissolve DDT in a solvent and then disperse it in water, why not forget about the solvent and just disperse the DDT directly in water? This would have lots of advantages—if it could be done. But it can't! The crystals of DDT are somewhat waxy; they stick together and form lumps. You can't grind the DDT to a fine powder, and even if you could it would not stay that way. But you can grind DDT with an inert flaky material such as talc, pyrophyllite, or clay and get a very uniform product containing up to 50% DDT. And while you are grinding the DDT and the inert material together, add small quantities of wetting agents and sticking agents. Then when you mix the powder with water, it will disperse readily, and when you spray it on your cows or rose bushes the powder that is left after the evaporation of the water will stay put and not blow away with the gentlest zephyr.

One pound of a 50% wettable powder to about 5 gallons of water makes a good residual spray for the control of flies in barns and on cattle, and about 30 pounds per 1,000 gallons of water is fine for dipping sheep and hogs for the control of ticks and lice. One disadvantage of the use of wettable-powder sprays is that they leave a white deposit on the walls, and this limits the use of such a spray to barns and similar buildings.

For agricultural purposes, the powders are mixed with water, usually in the ratio of about 1 to 2 pounds of 50% DDT powder per 100 gallons of water. Sulfur, Bordeaux mixture, organic fungicides, and other materials may be incorporated in the spray to make an all-round insecticide and fungicide.

Dust the Plants

Some farmers, as well as amateur gardeners, prefer to dust their plants rather than spray them. Such individuals will find powders specially prepared for them. These powders contain, most commonly, either 3 or 5% DDT, but mixtures of other concentrations can be purchased. These powders can also be obtained with copper or sulfur, or with other fungicides and insecticides; or the farmer or gardener may purchase the straight DDT powder and mix it with his favorite ingredients.

Save the Surface

If spraying a solution of DDT on your walls will leave a deposit that will kill insects for months, why not mix DDT with the paint used for the interior of houses and get a finish that will kill insects as long as the paint film lasts? Many imaginative individuals came up with this logical-sounding idea, and many exaggerated claims have been made. Now we can sift fact from fiction.

The ordinary oil paints and varnishes don't seem to be any too good for mixing with DDT. The DDT mixes with the paint all right, but the dried paint film doesn't have very good killing properties. It seems that the dried oil film traps the DDT and keeps it from coming in contact with the insects. That's one way to save DDT—just like covering the ice in the refrigerator with newspapers so it won't melt: You save ice but don't get very good refrigeration. If saving DDT is the object, better keep it in the can instead of locking it up in a paint film.

Some of the oil-bound water paints and synthetic resin finishes, however, seem to give good results. For some of these products claims have been made that they retain their killing action for over several months. To be effective, the binders must permit the DDT to migrate to the surface of the film where the insects can get in touch with it. Since the DDT on the surface will gradually vaporize and be lost, other DDT must take its place if the paint film is to retain its effectiveness.

One product of this type is sold under the trade name of *Pestroy.* It is a colorless, synthetic-resin liquid with 6% DDT. It can be brushed on screens, ceilings, stairs, or other surfaces, and dries in a short time to an almost invisible film which is lethal to insects but which will withstand considerable rubbing. The claims for this product are very modest: the manufacturer merely states that one application will remain effective for at least three months inside, and at least a month outside.

Chapter Five

Common Insect Enemies

The Lousy Louse

REMEMBER these immortal words of Robert Burns that you were forced to memorize back in the days when you were a little schoolboy or schoolgirl?

"O wad some Power the giftie gie us
To see oursels as ithers see us!
It wad frae mony a blunder free us,
An' foolish notion:
What airs in dress an' gait wad lea'e us,
An' ev'n devotion!"

And what prompted Burns to write these words of wisdom? Nothing but a lowly louse on the bonnet of a well-dressed lady who was piously sitting in church, entirely oblivious to the fact that her uncleanliness was to be the inspiration for a famous poem, entitled "To a Louse." This, seemingly, was the only louse in history that ever did anyone any good. Its countless brothers and sisters are at best merely loathsome creatures, and at their worst they are among the most deadly of man's innumerable insect enemies.

When speaking about lice, one must be very careful to differentiate between the three types that attack man: the body louse *Pediculus corporis,* the head louse *Pediculus capitis,* and the crab, or pubic, louse *Phthirius pubis.* Of these three, the body louse is the most dangerous for it is the principal carrier of a number of diseases, the most serious of which is epidemic typhus.

Fortunately, cleanliness is the enemy of the louse, and since about the only people in this country who seem to have an almost pathological dread of soap and water are those carefree citizens known variously as hoboes, tramps, and bums, it is only among this group of individuals that the body louse is found to any great extent in the United States. Thus, louse-borne diseases are of relatively little importance in this country. But in other parts of the world, the situation is quite the opposite. Millions of inhabitants of Europe, Asia, and Africa live under conditions of filth almost unbelievable to an inhabitant of a country where the greatest bulk of radio advertising is devoted to the sale of soap.

An adult body louse is a rather good-sized brute, about ¼ inch long, and grayish in color. It emerges from a whitish egg, or nit, which hatches at body temperature about 8 days after the egg is laid, and spends about 9 days in the nymphal stage, during which it sheds its skin three times as it grows to an adult. And if our louse happens to be a female, she begins to lay eggs about a day after she emerges as an adult, and she may live as long as a month, laying 4 or 5 eggs each day.

The body louse makes its home in its host's clothing, and it leaves its home several times a day to visit its host's skin and acquire nourishment. Sometimes the female lays her eggs on the hairs of the body, but usually she deposits them in her host's clothing, particularly in the seams and folds. And she glues her eggs to the fibers of the cloth.

Since the body louse does not live on the body but rather in the clothing, it is relatively easy to control this unwelcome boarder. All stages of the louse are killed by washing the garments in hot water or by dry cleaning. If a person changes to clean clothing every week, he will not have body lice.

But, where whole communities live in homes where cleanliness is not practiced, where soap is not available, and where anyone with a change of clothing is considered a plutocrat, the problem of louse control is a much more difficult one. But now with DDT, as results in Naples have shown, no individual or community need suffer any longer from the dreaded typhus and other louse-borne diseases. A single application of 10% DDT powder to all individuals in an infested community will completely eradicate the lice. One ounce of powder applied to the inner surface of undercloth-ing and another ½ to 1 ounce applied to the seams of the outer garments will continue to kill lice for months thereafter.

What's That In Your Hair?

Was little Johnny sent home from school recently with a note from the school nurse saying that he must get rid of lice before he would be permitted back in school? And did you feel deeply mortified at this insult to the cleanliness of your home? Don't feel too badly, for it takes more than cleanliness to keep away these little fellows. Maybe they just preferred Johnny's clean head to the dirty head of his schoolmate who brought the lice to school, to distribute unintentionally among all the children.

But now that the tell-tale nits have been spotted by the eagle-eyed nurse, don't get the idea that all you have to do is put Johnny under the shower and give him a good shampoo. The lice and nits are a little too tough for that: they can survive several good shampooings, and you can comb and brush his hair all you want, but some of the lice and nits will escape your most persistent exertions.

Before we tell you what to do, we feel that you should know that the head louse looks just about the same as the body louse. In fact, the head louse and the body louse are so similar that they can interbreed and raise families of lively hybrids. However, you know he is a head louse because he is found on the head. It's as simple as all that! But if you find a louse on your body he may be either a body louse or a crab louse, as you shall learn in a little while.

Is the head louse just a nuisance, or is he, like his brother the body louse, a carrier of disease? For a number of years the finger has been pointed at the body louse—"There's the carrier of typhus!" All right, he is! But that doesn't mean that he is the only carrier. One would certainly suppose from the similarity between the body louse and the head louse that the latter might also be guilty. And he is! It has been shown under experimental conditions that the head louse can transmit typhus, and there is plenty of reason to believe that he does this under natural conditions.

After all, the body louse is merely a development of the head louse. Primitive races who wear little or no clothing have no body lice. Yet, long before they first started to wear clothes, our naked ancestors had an abundant supply of lice on their heads. With the advent of clothing, some adventurous members of the head louse family migrated downward and established themselves in this new environment.

Just when typhus first appeared on the earth will never be known, for it was undoubtedly long before recorded history. However, because of the absence of body lice in these very early days, it seems likely that head lice were busy

FIG. 15. THIS SOLDIER IS TREATING THE INTERIOR SURFACES OF A BARRACK WITH DDT RESIDUAL SPRAY TO INSURE IMMUNITY AGAINST MOSQUITOES FOR SEVERAL WEEKS.
(Courtesy of U. S. Dept. of Agriculture. Photo by Madeleine Osborne)

Fig. 16. A Measured Quantity of a Household Spray is Atomized into a Peet-Grady Chamber in Order to Determine the Effectiveness of the Insecticide.
(Courtesy of Hercules Powder Co.)

FIG. 17. FLIES KNOCKED DOWN DURING A PEET-GRADY TEST ARE PICKED UP AND COUNTED. THEY ARE THEN TRANSFERRED TO A CAGE TO SEE HOW MANY RECOVER WITHIN 24 HOURS.
(Courtesy of Hercules Powder Co.)

Fig. 18. This Piper Cub Airplane is Spraying a DDT Formulation Over Mosquito-Infested Terrain. This Treatment Kills Mosquitoes and Larvae as Well as Adult Stages of Their Life Cycle.

(Courtesy of U. S. Dept. of Agriculture. Photo by Knell)

spreading typhus long before their body-dwelling descendants evolved. But, be that as it may. Kill the head louse! Get rid of him! At best he is a useless parasite; at worst he is a deadly killer.

Before the days of DDT, various remedies for the treatment of lice were used. These included larkspur lotion, kerosene in either vinegar or olive oil, and derris powders and lotions. With any of these materials, two or more treatments are required because they do not kill the eggs and they are not long lasting. Therefore, after you kill the lice you have to wait until the eggs hatch and then try to catch the new-born youngsters before they have a chance to enjoy their love life and start raising families.

If you'll just remember that DDT has long-lasting properties, you can readily see why it is effective against the head louse as well as the body louse. So grab the carton of 10% DDT powder and shake it thoroughly into Johnny's hair. He may object to having his brunet locks suddenly assume a grayish appearance, but he will forgive you when you explain that he will not have to wash his hair for at least ten days. The reason for this is that DDT has one thing in common with the other louscicides—it does not kill the eggs. Therefore, the powder must be left in the hair long enough to kill the young lice from all the eggs as they hatch.

If Johnny happens to be one of those unusual boys who insist on washing their hair the day after treatment, a second application of DDT powder should be made about 8 or 10 days after the first in order to get rid of the animal life that hatches from the eggs left in his hair. The lice that hatch during this 8- to 10-day period will not complicate the problem by laying more eggs, for it takes at least 10 days, and usually longer, for the new-born creatures to become sexually-mature adults.

Those who are in a hurry to get rid of the eggs as well as the lice can make use of the *NBIN* formula, which was developed during the war particularly for the control of the body louse, but which is equally effective against the head and crab lice. This material is applied in emulsion form, one part of concentrate to five parts of water. The hair is thoroughly wetted with the emulsion, and is then combed to insure a more thorough distribution. Although the eggs as well as the lice themselves are killed by a single treatment, it is a good idea to leave the material on the hair for 8 or 10 days in order to be sure that you get any lice that may have been hiding in your clothing while you were treating your hair. Since this material will retain its killing properties for at least two weeks after application, any stray lice that return to their home will wish they hadn't.

You probably will not be interested in mixing up some NBIN, but your druggist or your chemist friend can do it for you, for NBIN concentrate is merely a mixture of 68 parts of benzyl benzoate, 12 parts of benzocaine, 6 parts of DDT, and 14 parts of a dispersing agent, such as Tween 80.

Right Where It Hurts

The crab, or pubic, louse is not known to transmit disease, but he can sure make you miserable. He seems to know that scratching, particularly around certain parts of the human body, is frowned upon in good society. Therefore, he makes his home principally in the pubic region where he can bite those tender parts to his heart's content, knowing that you will do no more than merely squirm in your chair.

This louse, which gets its name from its crablike appearance, is shorter and much flatter and broader than his relatives, the body and head lice. And, unlike the body louse, the crab louse does not live in the clothing, but makes his home in the hair of the body. Therefore, it does no good just to put on clean clothes; you must use an insecticide which will kill him on the body.

In the past, Blue ointment, kerosene in vinegar or olive oil, and derris and larkspur lotions have been used against the crab louse, but DDT powder or the NBIN formula are much more effective, and are not as irritating to tender parts of the body as are derris or kerosene-containing preparations.

Since the crab louse lives in the hair of the body, all hairy portions, including the armpits, chest, the pubic and perineal region, and the legs should be thoroughly dusted with 10% DDT powder or treated with an emulsion of the NBIN formula, and the powder or emulsion should be rubbed in well with the fingers. One application of the NBIN formula will eradicate an infestation. It should be allowed to remain on the body for at least 24 hours in order to get any wanderers who were hiding out in the bedding or clothing. If you prefer to use the powder, leave it on for at least 24 hours before you take a bath, and repeat the application in about 8 or 10 days.

Your Bedtime Companions

Have you ever noticed how a person acts just after he is shown to his room in a hotel or rooming house? How he tiptoes very carefully over to the bed, grabs the covers, and, with a mighty heave, pulls them down? What he is seeking are some tiny, brown creatures, with the scientific name of

Cimex lectularius, but known far and wide as bedbugs. These creatures don't like the light, and our hotel guest has to move plenty fast if he expects to get a glimpse of them before they scurry to their hiding places.

Of course, another way to find out if a hotel is, or has been, infested with bugs is to look for bedbug powder on the mattress or to sniff the mattress to see if it has been sprayed with an insecticide. Since many of the preparations that have been used for bedbug control are not very effective, evidence that they have been used is usually a warning that during the night, if you remain awake, you will feel numerous sharp stabs as the bedbugs come out for their midnight snack.

If your hotel manager is smart, he can make certain that you will be the sole occupant of the single bed for which you will pay $5.50 in the morning. Even though some previous occupant of the bed may have brought to it a few choice specimens of bedbugs, there is no reason why the bugs should be permitted to perpetuate their race. For DDT is the perfect answer to bedbug control!

Either a spray of 5% DDT in deodorized kerosene or a 10% DDT powder will do the job. One treatment with either of these formulations will not only clean up the bedbug infestation, but will prevent re-infestation for at least 6 months and possibly for over a year. Three fluid ounces of the 5% solution or two ounces avdp. of the powder are sufficient to treat a double bed. But be sure to do a thorough job: spray or dust both sides of the mattress and pillows, the bed springs, and particularly the cracks and joints in the bedstead. Also treat the cracks and crevices along the window and door frames, behind pictures on the walls, and along baseboards and mouldings. All of these dark places may be hideouts for the bugs.

Whether to spray or dust is up to you—both are effective. But the use of the powder is indicative of the fact that bedbugs formerly occupied the premises, and the guest will probably spend the night imagining that he is being bitten, even though the bedbug population was reduced to zero long ago. The spray, particularly if a good deodorized kerosene is used, will leave no tell-tale deposit or odor. Of course, when the spray is used it takes a few hours for the solvent to evaporate, and the bed cannot be made up until it is dry. Incidentally, neither the powder nor the residue left after the evaporation of the spray solvent will harm your skin. So rest in peace—don't worry about either bedbugs or DDT poisoning.

The Ubiquitous Fly

He drags his legs through the frosting of your freshly made cake; he dunks his head in your glass of milk; and he flies over to lap up that little drop of milk on the nipple of the baby's bottle. But where was he an hour ago: crawling around on the manure pile, exploring the privy, or floating leisurely down the sewer on an unattractive piece of debris? That's the housefly—*Musca domestica*—for you. Here, there, and everywhere, but always up to no good.

Garbage, manure, and sewage are the preferred breeding places for flies. Here they lay their eggs, and within a period of about a week the eggs hatch to maggots, the maggots change to pupae, and the pupae develop into full-fledged flies ready to start a new generation. And since flies can live about a month, they can become the parents of numerous offspring before they finally pass on. In fact, it has been estimated that a single pair of flies left to enjoy life unmolested could become the parents, grandparents, etc., of about six trillion descendents in about six months.

If he were just a nuisance, we might grin and bear it, hard as that might be to do. But there is considerable evidence that old *Musca domestica* is public enemy No. 1, for he has probably committed more murders than all the gangsters and highjackers have ever committed. However, he is very tricky: it is about as hard to get the evidence on him as it is to convict a gang leader for anything except income-tax evasion. Everyone believes him to be guilty, but no one has been able to prove it.

We all know that during the warm summer months there are veritable epidemics of what is politely called "intesinal flu," but which is actually a whole group of diarrheas and dysenteries of bacterial or other origin. How these diseases are transmitted is not clear, but since these are intestinal diseases, the organisms that cause them are found in copious quantities in human feces, and it is at least possible that flies might carry the organisms from the feces of an infected individual—or from sewage—to food which is subsequently eaten by another. If this is true, better waste disposal and a systematic campaign to eliminate the fly should help to reduce the spread of infections. However, before we place too much blame on the fly, we should be honest and admit that there would probably also be less spread of intestinal infections if food handlers were more careful to wash their hands thoroughly upon leaving the toilet.

Flies and Polio

Poliomyelitis, or, as it is commonly but inaccurately called, infantile paralysis, is a dreaded disease. Few diseases of modern times strike more fear into the hearts of men than this virus infection which attacks the nerve cells that control the muscles, and which may leave its victim a cripple for life. It is this crippling aspect of the disease that is so frightening. Actually, polio kills fewer people than such common diseases as measles, whooping cough, and mumps.

Although it seems to have reached epidemic proportions only within the present century, poliomyelitis, apparently, is an old disease, and is much more prevalent than most of us believe it to be. Probably most adults have had polio at some time during their lives without knowing it, for contrary to common belief, most cases of polio do not end in death or paralysis; it is only those cases that do show the typical paralysis that are recognized as such by most physicians. Certainly, many adults have protective substances in their blood that immunizes them against further attack, and this indicates that they probably had the disease in a mild form earlier in life.

But this knowledge doesn't help much when we see a number of children suddenly stricken with the disease in its violent form, and watch them die or become paralyzed. What causes the disease? How is it transmitted? And what can be done to prevent its spread? These are the questions to which we would like to know the answers.

Apparently the virus of poliomyelitis enters the victim through the mouth, or possibly the nose, and gets into his alimentary tract from where it travels to his nervous system. The evidence for this is that the virus has been found in human stools and in sewage. How then, is it transmitted? Flies may be the answer, for poliomyelitis virus has also been found in flies. But more dramatically still, food left exposed to flies for from 12 to 24 hours in several epidemic areas in 1944, became contaminated with the virus, as was revealed when the food was fed to chimpanzees. These animals, although they did not show any evidence of paralytic poliomyelitis, showed virus in their stools for the next few months, and this virus when passed on to monkeys caused typical poliomyelitis lesions.

Do flies play the same part in the transmission of polio that mosquitoes do in malaria and yellow fever? We don't know. But let's kill the flies and see what happens to the spread of polio.

The summer of 1945 was a good time to try out this idea, for Rockford, Illinois was stricken with a severe polio epidemic, and the effectiveness of DDT had been well established. Within a few weeks, 17 people had died from polio in Rockford, and many times that number were ill. Get out the DDT! And that is what Dr. John R. Paul of Yale University and the scientific expedition that he headed did. The town of Rockford was sprayed, and sprayed thoroughly, and many flies paid the penalty for their possible association with polio. The polio epidemic gradually subsided, but whether the DDT campaign contributed to the decline is not known. It takes more than one experiment to give conclusive results.

Some day we may know the role of the fly in the spread of polio, and if we find out that he is a killer as well as a nuisance, we can be sure that an aroused populace will fill its spray guns with DDT and wage relentless warfare against this flying carrier of filth.

The Fly and the Horse

Have you ever stopped to consider the relationship between the fly and equine populations? Unless you are a member of the younger generation you can remember the days when our city streets were covered with evidence that the horse reigned supreme in the field of transportation. He pulled the milk wagon, the grocer's delivery wagon, and the brewery truck; and the surrey with the fringe on top was a reality instead of a popular song.

Being uninhibited in their toilet habits, the multitude of horses furnished work for numerous whitewings; but it was a losing battle for the pushers of the broom: their task was never finished. This was a paradise for flies: they liked the manure-covered streets, and the manure piles behind every stable furnished ideal breeding places for them. The result: flies, flies, flies! Every time one went into or out of the house, a swarm of flies, lurking around the screen door, made a dash for the cooler interior of the house and the tempting food upon the dining room or kitchen table.

Who could visualize in the early days of this century that the chugging one-cylinder horseless carriage would some day banish the horse from the city streets, and with it, the fly? Yet, that is what has happened. In our metropolitan areas today, the old gray mare "ain't what she used to be," and the fly is a negligible factor in the transmission of disease.

In rural regions, however, the fly is still with us in quantity, for the tractor has not yet eliminated the horse, and no one has invented a satisfactory substitute for milk or beefsteak. The farmer, however, can now make his premises as free from flies as city streets by simply treating his barns and animals and manure piles with DDT compositions. Just to give you a few examples: In experiments where manure piles were treated with a ¼% DDT solution, no flies subsequently emerged, and barns sprayed with DDT solution showed a 99% reduction in the fly population even 30 days after treatment.

An Island Paradise

Out in Lake Huron, off the northern tip of the lower peninsula of Michigan, lies Mackinac Island, a delightful spot where the cool lake breezes keep the temperature down to reasonable levels during the summer months when folks swelter in their city homes. It is no wonder, then, that Mackinac Island has been a noted summer resort for many years. The island is rather large, and vacationers at resort hotels don't like to walk. In the days when Mackinac Island first became a summer resort, the horse and carriage were the fashionable means of transportation over short distances, and horses and carriages became as much a part of the island scene as the fat dowagers who eased their broad posteriors into chairs on the hotel's veranda.

A few hundred miles to the south of Mackinac Island, in a city called Detroit, a new mode of transportation was perfected, and the product of Henry Ford and others could soon be found in practically every remote corner of the earth—but not on Mackinac Island. The proprietors of the resorts decided that the exhaust of motor cars would not be allowed to contaminate the pure lake air, and that the soft neighing of the horse was preferable to the noise of the horseless carriage. So today when you step off the steamer at the dock, you will be met, as were your parents and grandparents, by a line of horses and carriages to transport you to your destination.

But life on Mackinac Island has not been entirely a bed of roses, for the penalty for retaining the horse has been a plague of flies. And it is difficult indeed to enjoy peace and quiet while pesky flies are buzzing around and biting chunks out of one's epidermis.

And then came DDT! The Mackinac Islander's were not impressed when they heard about the remarkable effectiveness of this insecticide against the typhus-bearing louse. After all, only well-heeled gentry are encouraged to spend their time on this oasis in a mechanical age. And it can be presumed that body lice are quite rare among folks who take a bath every Saturday night. But when it was learned that DDT and flies are incompatible, the natives pricked up their ears. Why not have one's cake and eat it, too? Or in plain words, why not keep the horses, but get rid of the flies? Spray the island from one end to the other with DDT. That ought to do the trick! And it did! For the first time in the memory of the oldest inhabitant, Mackinac Island was free from flies. A public celebration was held to celebrate this epoch making event; a huge bonfire was made, and the gleeful citizens burned their fly traps. Perhaps, later on, they wished they hadn't, for flies breed rapidly, and a few surviving members of the species can soon repopulate wide areas.

Contented Cows

With our typical conceit, we always look at every problem from our own point of view. We believe that in our battle with the insects we have right on our side. They attack us and, therefore, we have the right to kill them. But one could put up a good argument to the effect that insects have as much right to the earth as we have—perhaps more, since they have been here longer. Most of us wouldn't even listen to such an argument, for, after all, aren't we God's chosen creatures? And when one section of mankind fights another in our periodic wars, doesn't each nation maintain that God is on its side? But what we meant to talk about was cows.

Insects attack us; but they also attack other animals. Ordinarily this would not interest us in the least, but where the cow is concerned we do take a personal interest. Our interest, of course, is entirely selfish. The mere fact that cows might suffer from fly bites is not, in itself, sufficient reason for us to kill the flies that attack the cows. But we get milk from cows, and—at least so we have been told—a cow must be contented if she is to give large quantities of wholesome milk.

It is very fitting, therefore, that the Walker-Gordon Farms—where they specialize in contented cows—should have been one of the first dairies to use DDT on a large scale to cut down the fly population. Results were very gratifying: the fly population was cut to almost zero and, we presume, the cows in appreciation of their increased contentment reciprocated by increasing their yield of milk.

In the few years since DDT first became available, thousands of dairy barns have been treated with no damage to the livestock but with a great improvement in Bossy's life and with more milk for the farmer. Reports indicate that cows pestered with flies give 3 to 8% less milk than their fly-free sisters.

There are three species of flies that annoy cattle—the housefly, the stable fly, and the horn fly. Of these, the housefly is the greatest nuisance because it is usually present in the greatest numbers, although swarms of the much smaller horn fly are often found on livestock. Unlike the housefly, which feeds on the body secretions of animals, the stable fly and the horn fly feed upon the blood of animals. The housefly lays its eggs in manure and decaying vegetation; the stable fly lays its eggs in fermenting plant products; and the horn fly lays its eggs only on fresh cow manure. A knowledge of their breeding habits is of considerable help in the control of these insects: treat manure piles and decaying vegetation with DDT and keep down the fly population.

To kill the flies around the barn, both the building itself and the cattle should be treated. A residual spray applied to the walls of the barn twice a year—May and August for best results—will reduce the fly population to a very low figure, for all flies that touch the treated surface will die. A 5% DDT-kerosene spray, a 5% emulsion, or a 2½% dispersion of wettable powder (approximately 2 pounds of 50% wettable powder to 5 gallons of water) are all satisfactory for application to barns, but of these three, the wettable powder is perhaps the most popular, for it is nonflammable and it is not readily absorbed by porous surfaces—rough wood and concrete—such as are found in barns. For best results, a gallon of the 2½% dispersion should be used for approximately each 300 square feet of surface.

For direct application to the animals, the oil solution, of course, should not be used, but either the emulsion or the dispersion of wettable powder can be applied without harm to the animals. A single application of about a 2½% emulsion or dispersion of wettable powder, applied as a spray at the rate of about 1 quart per adult horse or cow, will effectively control the horn fly as well as other flies for a few weeks or more. When applying the spray, particular attention should be paid to the belly, rump, and back.

An alternative method of applying DDT to animals is by means of a dip, but when a dip is used the concentration of DDT should be much lower than when a spray is used:

an emulsion diluted to about ¼% DDT gives good results. About 2 gallons are required for each adult animal.

The Female of the Species

The relentless battle between man and insects is often carried out indirectly: the insects destroy man's food, or, in the case of flies, contaminate it with disease germs. But there is nothing indirect about the mosquito. When you sit out on your lawn on a fine summer's evening, you are soon attacked from all sides by a buzzing, blood-thirsty horde, and your tender epidermis is soon punctured in numerous places by sharp, hollow swords. Nor is it any consolation to know that the attack would be twice as bad if the males, instead of just the females, had mouth-parts capable of piercing your skin.

Mosquitoes belong to that class of insects known as *Culicidae,* a very large family indeed, being composed of a few subfamilies and numerous species. Not all of the species attack man: in fact, many of the species aren't blood-suckers at all, and of the blood-suckers many prefer to feast on birds and on mammals other than man. To keep from getting too technical, let's limit our attention to the *Culex, Anopheles,* and *Aedes* mosquitoes, for these members of the subfamily *Culicinae* comprise our pesky household mosquitoes as well as the deadly carriers of malaria and yellow fever.

The various species of the genus *Culex* are supposed to be harmless, as far as the transmission of human diseases are concerned, but no one will disagree with the statement that the word "nuisance" is a very mild term to apply to these widespread destroyers of our peace and quiet. And are we sure that they don't carry disease from man to man? It is known that some species of *Culex* do transmit blood diseases of birds and animals, and it is not beyond the realm of possibility that some of the baffling diseases of humans might also be transmitted by means of these unwelcome intermediaries. Let's not forget that not many years have elapsed since malaria was traced to *Anopheles* and yellow fever to *Aedes,* and still fewer years have elapsed since two other tropical diseases, dengue and filariasis, were shown to be mosquito-borne.

The method of attack that has proved so successful in cutting down the population of malaria- and yellow fever-bearing mosquitoes is still the best: Eliminate their breeding places, or at least treat their breeding places so as to disrupt their normal cycle of propagation. Some mosquitoes lay their eggs on the surface of water; others lay theirs on the ground after the pools have dried out, and the eggs remain there until rain or melting snow refills the pools. The eggs of some mosquitoes hatch within a short time after they are laid; with most species, however, the eggs remain as such over the winter; and in certain other species, it is believed that the eggs may remain on dry ground for as long as several years, waiting for the rain that will enable them to hatch.

The marshlands along the ocean, the innocent-looking meadow pond, the rain barrel alongside the house, the rain-filled tin cans on your refuse pile, these are the breeding places of mosquitoes. Here they lay their eggs, here the eggs hatch into larvae—those well-known "wigglers" which you have seen many times—here the larvae go through four molts and change into pupae, and here after two or three days, the pupae shed their skins and emerge as full-fledged flying mosquitoes.

It's very simple, then. Get rid of the water and you get rid of the mosquitoes! And if you can't get rid of the water, cover it with a film of oil so the larvae can't breathe. These are the methods that our army engineers applied so successfully in Panama, where they fought and defeated the yellow fever-carrying mosquito *Aedes,* the killer that had for so long held up construction of the canal across that narrow strip of land.

But drainage or oil treatment aren't always feasible. You know that during a wet spell the mosquito population increases phenomenally. There may be no ponds or lakes or marshlands near, yet the mosquitoes seem to find plenty of places to breed. The damp woods and fields offer innumerable little wet spots for mamma mosquito to lay her eggs and for the results of her love life to pass through their various stages of development. After all, a mosquito larva is not very big: it doesn't need much space. That's all right for the mosquitoes, but what are we going to do about it? Shall we try some DDT?

We know that a DDT space spray or a shot from an aerosol bomb will knock for a loop any mosquitoes present. We also know that a residual spray leaves a deposit of DDT that lasts for several months and kills any mosquito that comes in contact with it. These methods are extremely effective. The U. S. Public Health Service, in its battle against the malaria-bearing mosquito, treated the walls of practically all the sharecroppers' shacks within a 36-square mile area near Helena, Arkansas, with a DDT residual spray. Cost: 74 cents per shack for material and labor. Results: A 94% reduction in the mosquito population for at least 2 months. Not bad!

Perhaps you are familiar with the ferocious and enormous mosquitoes that inhabit the miles of salt marshes along

FIG. 19. TO KILL MOSQUITO LARVAE IN FLOWING WATER, A DRIP CAN FEEDING A DDT IN OIL SOLUTION IS VERY CONVENIENT.
(Courtesy of Geigy Company, Inc.)

Fig. 20. A Rotary-Type Hand Duster Being Used to Treat a Mosquito-Breeding Place with DDT.
(Courtesy of U. S. Dept. of Agriculture. Photo by Knell)

Fig. 21. These Walker-Gordon Cows Will Be More Contented After the Dairy is Sprayed With a Water Suspersion of DDT.

(Courtesy of Geigy Company, Inc.)

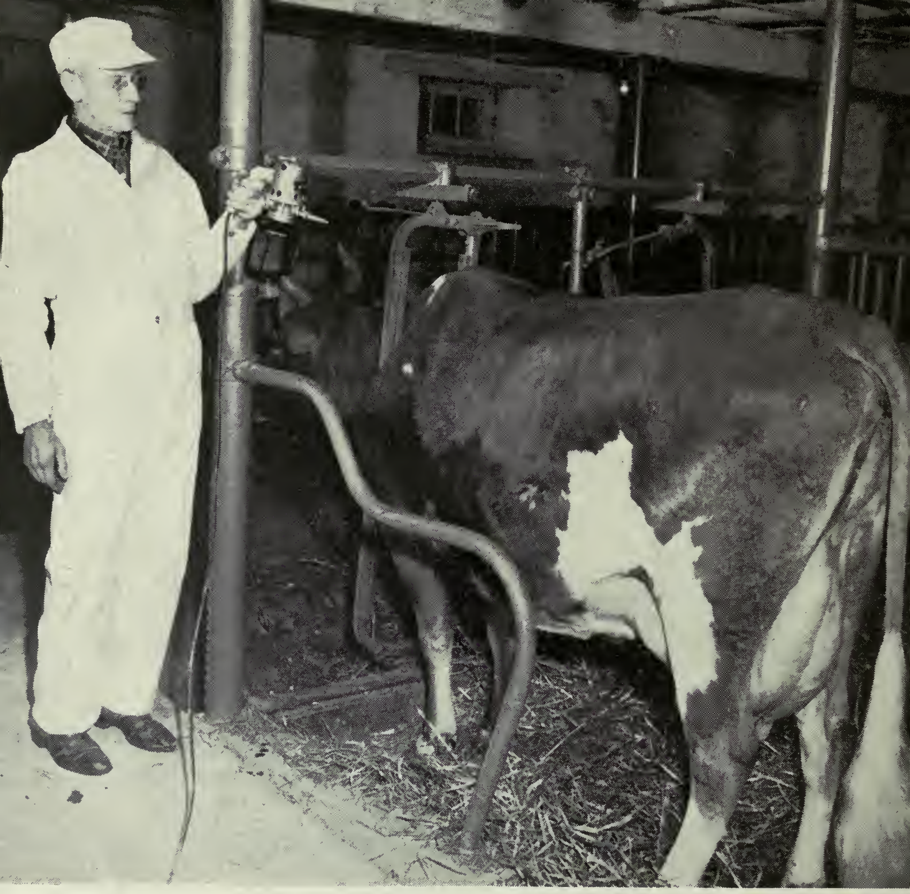


Fig. 22. Cows Kept Free from Flies by Direct Application of DDT Will Give from 3 to 8% More Milk Than Their Untreated Sisters.
(Courtesy of Hercules Powder Co.)

the New Jersey coast and make periodic forays into the neighboring towns and villages to suck the blood of the hapless inhabitants and visitors. However, New Jersey is rather sensitive about its reputation as the mosquito capitol, and decided to do something about it. A DDT-oil solution sprayed over thousands of acres of marshlands killed millions of mosquitoes and made life in New Jersey much more comfortable. Unfortunately, in their anxiety to do a good job, the mosquito exterminators used more DDT than was necessary, for the officials in charge were greatly disturbed to find that many fish also succumbed to this mass attack.

You may also have read about what they did in New York to the mosquitoes along Jones beach—that magnificent stretch of sand that is covered in the summertime with a few beautiful and thousands of ugly, practically nude bodies, much to the delight of the mosquitoes. One fine day, before the bathers were permitted on the beach, clouds of a DDT-oil mixture were generated and were carried inland by the gentle ocean breeze. That afternoon and evening the bathers were pleased, but surprised, to find that their fat bodies were, for once, not blood banks for mosquitoes.

For our military campaigns in the Pacific, mosquito control was essential. You have heard of how entire islands were treated with DDT and practically all insect life eliminated. One Pacific island of 6,400 acres was sprayed with a DDT-oil solution from a torpedo bomber, flying at a speed of 125 miles per hour at an elevation of 150 feet. Ten gallons of solution were sprayed per minute, and only 2 quarts were applied per acre. Yet, this was sufficient to wipe out all the insects.

Saipan is a name that will long be remembered. In addition to the Japs, our fighting men there had to contend with a dengue-type mosquito. An airplane was loaded with DDT powder instead of with bombs, the island was thoroughly dusted, and not a mosquito or fly was to be seen. Within a few weeks, dengue was no longer a problem to the medical service.

But we were speaking about treating the breeding grounds of the mosquito. Let's get back to the subject. We said a while ago that oil applied to stagnant bodies of water will kill the larvae. But, one quart of 5% DDT-oil solution is as effective as 10 to 14 gallons of oil alone. In fact, DDT is probably the most effective mosquito larvicide yet developed. As little as 1/10 pound of DDT per acre applied as an oil solution, a dust, or an emulsion to water surfaces or vegetation prevents the development of larvae for weeks. For stagnant waters, 1 part of DDT per 100,000,000 parts of water will kill the larvae and pupae of many types of mosquitoes, although for some species, a somewhat higher dosage is required.

Ants in Your Pantries

Ants are the delight of sociologists, for in social development ants are centuries ahead of man. A colony of ants busily engaged in carrying out the multitudinous activities of their daily life is a sight worth witnessing. Yet, it is a depressing experience, for one can't help but feel that ants know much more about efficient organization of community life than man can ever hope to learn. Watch the ants closely! Each one seems to know just what to do— and he does it. No strikes, no picket lines, no unemployment! But maybe ants are just dumb. What's the sense of working all day, every day? Where does it get you anyway? Nevertheless, it is very intriguing the way ants do things. A few males and females are hatched, the males mate with the females and, having completed their life's work, immediately proceed to die, and then each inseminated female, or queen, establishes a new community. To maintain her position as head of the new colony, the queen sees to it that her offspring for the next few years are all workers; and to make sure that the workers keep their minds on their work instead of mooning around, the mysterious law of the colony usually sees to it that the workers are sexless. A similar arrangement in human society would have obvious advantages, but it is doubtful if the idea would be readily accepted by the mass of our citizens.

One of the big tasks of the workers—perhaps the most important—is the gathering of food, not only for themselves but also for the queen and the numerous crops of developing larvae. Some ants find other insects very tasty, but most of the ants we encounter are vegetarians by nature. And they are particularly partial toward sweets. As they forage over wide areas for their nourishment, some ants invariably find their way into your home and soon locate your hoard of sugar and other foods on your pantry shelves. If most of us stumbled upon what to us was an almost inexhaustible supply of food we would keep that information to ourselves and would do our best to keep our neighbors from finding out about it. But that is because we are uncivilized. Ants are different. They are not selfish like we are: they immediately broadcast word of their discovery to all their fellow workers, and soon the safari is on. Where yesterday there was a single ant, today there are hundreds, all busily engaged in carrying away food that we had hoped to have for our very own.

The ant is probably not a carrier of human diseases. At least, if he is we don't know about it. When he stays outside of domiciles, he doesn't bother us much except when we go out into the wide-open spaces for a picnic. And then it is our own fault: anyone foolish enough to spread a cloth in some grassy glen and cover it with food deserves no sympathy if ants start carrying away the sandwiches. If we invade the home of the ant, he has a right to fight back. And if he invades our home, he deserves what he gets; and today what he gets is probably DDT.

There are numerous species of ants, and not all of them can be controlled by the use of DDT, but it is very effective against many of the common species that invade the home. Either a 5% DDT-kerosene spray or a 10% powder can be used for the control of ants in buildings. Since the spray leaves no noticeable deposit, you will probably prefer it. Spray behind and beneath baseboards, behind window sills and frames, about sinks in the kitchen and bathroom, all table legs and chair legs, both sides of pantry shelves, and all cracks and crevices leading to the outside of the building. A single application will control many species of ants for several weeks, and some species that do not respond to DDT alone can be eliminated by means of a 10% DDT dust containing 1/10% pyrethrins.

To clear away ants from nests, sprinkle a little 10% DDT powder around the openings to the nests. As the ants go in and out of their home they will walk through the powder, much to their great discomfort. As a result, the nest will usually be abandoned within a very short time.

The Wood Eaters

In this day of the housing shortage, many old houses that have remained empty for many years suddenly acquire tenants. Sleeping in some of these houses is probably better than sleeping on park benches, for at least one has a roof over his head, even though it may permit the passage of copious quantities of rain. But although there may be a roof, there probably won't be much of a foundation, for although the house may not have provided shelter for humans for many years, it probably has been a source of food for many generations of termites.

Termites, or white ants, like the true ants, are highly developed social insects. Each colony has its queen and, more surprising, it also has a king. Unlike the true ants, the male termite survives the nuptial night and continues to live in harmony with his mate, constantly displaying the affections that every wife has a right to expect from her spouse. But in addition to the royal family, there are the workers, usually sexually undeveloped, and a special caste of professional soldiers with enormous heads and mandibles. Although it is not nice to make slighting remarks about the military caste, the evidence is that the soldier termites don't do a very good job of protecting the colony. Like the military castes of many of our nations, the termite soldiers have, apparently, assumed a position of importance all out of proportion to their true value.

The common termites make their homes in the ground and send out tunnels to building foundations, wooden floors, and other sources of cellulose, which they are able to digest by means of certain bacteria in their intestinal tracts. Regardless of how much we dislike these destroyers of our homes, we must admit that they are good engineers. They always leave enough of a timber to prevent it from collapsing on them. Thus, at first glance the foundation of your prospective home may look pretty good; but if you penetrate the outer shell you will probably find nothing but a sponge-like, honeycomb structure which will collapse when subjected to a little extra stress.

Perhaps the best thing to do if you have termites around is to get out the 5% DDT-kerosene mixture and treat the soil around the timbers you want to protect. One treatment will remain effective for at least two seasons.

A Dog's Life

When Fido stretches out on the living room rug for a well-deserved rest after a day of chasing cars or just hanging around with his girl friend, he doesn't rest peacefully. Every few minutes he twists himself into some grotesque position and scratches his neck or some other portion of his anatomy with his hind legs. Or else he gives a little bark and suddenly sinks his teeth into the hair on his belly as he tries to bite a savage little devil with a formidable mouth equipped for piercing the skin and sucking the blood.

And if you are the owner of a dog or cat, you know what a flea bite feels like, for fleas do not hesitate to vary their diet with a little human blood. If for no other reason than that he is an annoying pest, the flea deserves to be exterminated. But he is more than that—he is one of man's most dangerous insect enemies. Untold millions of humans have lost their lives from diseases transmitted by fleas. Bubonic plague—the infamous Black Death of the 14th century—is still with us, and this disease is known to be transmitted from rats to men by the bite of the rat flea. And even the dreaded typhus, which is transmitted principally from man to man by the louse, seemingly originates in rats and gets started in man by the bite of a flea. How many other diseases we acquire in a similar manner we don't know, but a mass of evidence is accumulating to show that many animals and birds, both wild and domesticated, can act as carriers of human diseases, and that these diseases are transferred to our bodies by the bites of fleas, ticks, and mites.

There are several hundred species of fleas, but they are all similar in habits and resemble each other in appearance. If all species would remain exclusively with their preferred hosts it would not be so bad. But they don't. A rat flea may prefer a rat to a man, but when a rat dies and the fleas leave him, they'll become companions of men if no rats are readily available. And as for cat and dog fleas, they make themselves right at home in our houses.

The eggs of fleas are laid on the body of the host animal, but they either fall off or get shaken off to the ground or floor. Thus, they become scattered about the floors of dwellings and the sleeping places of infested animals. Carpets, rugs, upholstered furniture, and even your bed may become depositories of flea eggs. And here the eggs hatch to larvae. The larvae are not parasites: they find enough food in the decaying animal and vegetable matter in the dirt in which they live. But when they become adults, they change their habits. Now they live on animals.

Since dogs and cats are about the only animals that people ordinarily permit to share their homes, the common fleas that you are likely to encounter are dog or cat fleas. Of course, if rats inhabit your premises there will probably be some rat fleas around, too.

To get rid of fleas on dogs, dust the animals thoroughly with 10% DDT powder—about 1 tablespoonful is sufficient for an average-size dog. The fleas will start to die in about

10 minutes, and within about two hours they will all be dead. However, since DDT acts as an intoxicant, the fleas show increased activity for some time after the dog is dusted. One advantage of the DDT treatment is that the dog will remain free from fleas for at least several days after a single application. Therefore, a dusting once a week should keep your dog perpetually flea-less.

But treating the animal itself is not enough since the eggs and larvae are scattered around the house. Therefore, you should spray the sleeping places of dogs, and infested floors, rugs, overstuffed furniture, basements, and rat burrows with 5% DDT-kerosene spray. Or, for those areas where staining or a powdery deposit can be tolerated, a 10% DDT powder, a 5% DDT emulsion, or a 2½% suspension can be employed in place of the kerosene spray. DDT is particularly effective against flea larvae, so treating the premises is particularly advantageous since it kills the insects before they reach the biting stage and hop on your dog or bite your leg.

Unfortunately, since cats lick themselves, they should not be treated directly with DDT powder for they might lick enough to become sick. However, treatment of their sleeping places and other infested areas, as described above, should be sufficient to get rid of the fleas.

Tick, Tick

Dogs not only harbor fleas, they also have ticks. And these little blood-sucking insects are just as bad to have around as fleas. Of course, your dog is by no means the only host to ticks: there are hundreds of species of ticks, and they are found on practically all kinds of domesticated and wild animals and birds. Among the diseases that ticks carry is Rocky Mountain spotted fever, which is transferred from certain species of rabbits, and possibly other rodents, to hunters, trappers, and campers who are unfortunate enough to get bitten by ticks that had been living on diseased animals.

Although the various spotted fevers have not yet reached epidemic proportions, there is always the possibility that a terrible epidemic might break out at any time, for many species of animals and birds are reservoirs of these diseases, and these animals all have ticks which can, if given a chance, puncture your skin and inject the deadly virus. The potentialities of the situation are quite evident from the fact that the American dog tick can transmit the eastern strain of spotted fever. The moral is: get rid of the ticks. This is not too difficult. Premises of residences, parks, and camp sites can be freed from this tick by spraying the vegetation with a ½% DDT emulsion at the rate of 3 pounds of DDT per acre. However, for direct application to infested animals, DDT dusts and dips have not proved as effective as the older rotenone preparations.

As far as you are concerned, the American dog tick may be of little interest, for the common tick of dogs is the brown dog tick. Fortunately, this tick can be controlled very nicely with DDT. In fact, treatment of the animal and the infested buildings for the control of fleas will also control the brown dog tick. So just use the 10% DDT powder on the animals and the spray or powder around the house and everything will be under control. But when treating buildings, be sure to dust or spray the cracks and crevices around baseboards, for these provide good hiding places for ticks.

We can't go into a lot of details for the control of all kinds of ticks, but horse lovers might be interested in the fact that a single treatment of horses with $\frac{9}{10}$% DDT in soluble pine oil emulsion will kill the winter horse tick and prevent reinfestation of the animals for a few months. And our poultry raisers might like to know that a single treatment with a 5% DDT-kerosene residual spray will keep their poultry houses free from ticks for at least three months. The spray, of course, is not applied to the chickens, but to the perch holes, and cracks and crevices in the poultry house, and other potential hiding places of the fowl tick.

Down on the Farm

We have spent considerable time telling you about a number of insect pests that make life miserable for you, and have told you how DDT can alleviate your misery. Let's now devote a little attention to some other insect enemies, who, like the late Adolph Hitler, are strict vegetarians. We told you a while back how DDT won its spurs when it saved the Swiss potato crop. Let's see what else it can do for our hard-working farmers and for our numerous gardeners who spend the hot summer months trying to breathe some life into a row of wilting lettuce.

A few mosquitoes on your skin may raise a few lumps and cause you to scratch—and, incidentally, to swear—but a horde of pretty striped beetles can ruin the farmer's crops, causing him to lose a lot of money and, as a result, raising your food bill. From a purely dollar-and-cents point of view, DDT means much more to the farmer than it does to the apartment-house dweller, whose entomological knowledge is limited to flies, mosquitoes, ants, moths, and perhaps cockroaches. It's a little too early to get the whole story about DDT for agricultural purposes, for it takes several years of testing to find out what an insecticide can or can't do against the multitude of plant pests, but a lot has been found out in the few years since the lethal properties of DDT were first discovered. Here are just a few examples:

In addition to its great effectiveness against the Colorado potato beetle, as was mentioned in an earlier chapter, DDT is highly effective against a number of other insects that attack potatoes, as well as those that attack peas, beans, cabbages, corn, onions, cotton, and many other field crops. Furthermore, it does a fine job against the numerous moths and other insects that attack fruits—peaches, apples, pears, grapes, citrus fruits, and others. The flower lover will be interested to know that DDT is probably the best insecticide to use on his rose bushes as well as on his chrysanthemums, snapdragons, and other flowers. If you are not a gardener or a farmer, and if you would rather buy your flowers at the florist than raise them yourself, this information will leave you cold. But if you do engage in "green thumb" activities, you will want to know more about it. To satisfy everyone, we have devoted a latter section of this book to specific uses for DDT in agriculture, and there we tell you what preparations to use and how to use them. But whether you raise food or merely eat it, you should know that DDT should not be used on fruits or vegetables such as cabbage in the later stages of their development, for under such conditions sufficient DDT might be left on the produce as it goes to market to give the consumer a slight case of poisoning. However, if satisfactory methods are developed to remove DDT from fruits after they are harvested, it will probably prove advantageous to continue the use of DDT for a longer portion of the growing season.

In order to give a complete picture, it should also be emphasized that DDT can't be used safely on all plants, for some species of the vegetable kingdom are poisoned by it. For example, it is harmful to cucumber and melon vines, and other curcubits. And, it should not be used on tomato plants. The best advice we can give is: Follow the instructions on the label of your insecticide, and heed the advice of your local agricultural specialist.

Beauty and the Beasties

Butterflies and moths are lovely creatures. With their gaily colored wings and their gentle, unhurried motions, they seem to us to be the aristocrats of the insect world. But every school child knows that in an earlier stage of development these beautiful, carefree, flying insects are nothing but ugly, squirmy caterpillars, whose only object in life seems to be to eat up all the vegetation in sight. Remember how our teachers in the first or second grade used to tell us about the silkworm? Of course that was way back before the Pearl Harbor episode, in the days when Japan was a group of beautiful islands known to most Americans chiefly for its kimonos, rice, chop sticks, and geisha girls. Anyway, our teachers used to tell us that the silkworm moth would lay her eggs, the eggs would hatch to caterpillars—the silkworms themselves—and the worms, after gorging themselves on lots of tender mulberry leaves, picked by the slender hands of Japanese maidens, would eventually wrap themselves up in silken cocoons, in the hopes that some day they would emerge as their ancestors did, as full-fledged flying moths, ready to heed the call of nature to perpetuate their race.

Alas for most of these dreams: the Japs would take the cocoons and dunk them in hot water to kill the worms inside, and then they would unwind the silk which eventually would be converted into sheer hosiery to cover some beautiful and many not-so-beautiful American legs. This, however, was long ago. Things have changed a lot since the Du Pont Company, by virtue of clever advertising, convinced our American females that if they want to be whistled at—and what woman doesn't?—they must encase their underpinnings in Nylon.

But take your choice, Nylon or silk. We don't care! In fact, if your legs are sufficiently free from blemishes and not too fuzzy, go around barelegged. We only mentioned the silkworms, anyway, as an example of the relationship between butterflies and moths and caterpillars. And we aren't going to get into an argument as to the difference between moths and butterflies. Our bug collector friends tell us that they are both members of the class of insects known as *Lepidoptera,* and as far as we can find out the division of this group of insects into butterflies and moths is entirely an artificial one. In general, moths fly at night and butterflies fly in the daytime. Furthermore, when butterflies are at rest they generally fold their wings together above their backs in a vertical position, while moths either wrap their wings around their bodies, spread them horizontally, or fold them in a roof-like manner over their abdomens. To all of which you will probably say: "So what?"

But to get down to business. Moths and butterflies, in spite of their beauty, are very destructive. Not that they do direct damage, but because they are the parents of trillions of caterpillars, each of which eats many times its weight of vegetation. These are the insects that destroy millions of dollars worth of fruit a year, as well as our shade and forest trees. And of course, one member of the species dearly loves your winter suit and any other woolen garments you may have around.

Perhaps you are familiar with the gypsy moth, one of the most destructive pests of fruit and forest trees we have, particularly in the eastern part of the country. Although it doesn't make much difference any more, the gypsy moth is a native of Europe, and was brought to this country in 1866 by a French naturalist who was experimenting with silkworms. Some of his specimens escaped to the woods, and now we spend millions of dollars a year in trying to control this one insect alone.

But now DDT has entered the battle between man and the moth, and the moths had better watch out, for they just can't take it. Spray your clothes and other woolens with a 5% DDT solution, and the deposit left after evaporation of the solvent will keep your garments free from moths for at least six months. However, if you have your clothes dry cleaned, the naphtha or other solvent your cleaner uses will dissolve out the DDT, so you will have to re-spray the freshly-cleaned garments. Deodorized kerosene can be used as the solvent for your DDT moth-proofing spray, but you will probably prefer to have the DDT dissolved in cleaner's naphtha, for it evaporates much more rapidly than does the kerosene. Incidentally, DDT kills both the adult moths and the larvae by contact.

For the control of the gypsy moth, tent caterpillar, and similar pests on your shade and fruit trees, you will probably prefer to use a spray prepared with about 1 pound of 50% DDT wettable powder per 100 gallons of water, or an emulsion containing about 1/10% DDT. For large areas of forest trees, the application of a DDT-oil spray or an emulsion by airplane is not only effective but very economical. Let's look into the matter a little more thoroughly.

Homes in the Raw

With millions of men and women searching frantically for non-existent homes, the housing shortage has developed into perhaps the principal postwar headache. And houses, at least most of them, are built from lumber. We no longer have to be preached to by conservationists to be impressed by the fact that our forests are among our most important natural resources. When you have to pay $80 or more a thousand feet for unseasoned, knotty boards you know that a good tract of timber land is worth more than a good gold mine. You also realize that any destruction of our timber reserves affects not only the owners of the tracts, but all of us.

Signs in our forested areas admonish us to "Break your match! Put out your campfire! Help to prevent forest fires!" Forest fires take a terrific toll of forest trees every year, as blackened stumps all over the country testify. And everything we can do to prevent such destruction should be done. But what about the less spectacular but greater destruction caused by the ravishes of insects? A news item about how Montclair, New Jersey, faces the loss of its more than 4,000 elm trees because of the Dutch elm disease does call our attention to the fact that even mighty trees can fall prey to enemies of insignificant size, and anyone who sees his favorite shade trees dying in the prime of their lives cannot help but feel a little sad. Try to imagine, then, destruction of this type multiplied many thousand fold, for that's what is happening to our forests.

Among the serious insect pests that are ruining our forests are the spruce budworm; the gypsy, brown-tail, and pine-tip moths; the hemlock looper; the Saratoga spittle bug; the red-headed pine sawfly; and the white pine weevil. Of course there are many others, but that gives you some idea of what our forest trees have to contend with.

The Agricultural Research Administration of the U. S. Department of Agriculture, in cooperation with several other organizations, has carried out a number of investigations on the control of forests insects by the use of DDT. Although much still remains to be learned, there is no question about the effectiveness of this new insecticide. In general, no more than a pound of DDT per acre is required, and this amount will not kill birds or animals. In fact, with proper methods of application, ¼ pound per acre, or even less, is sufficient, and where there are fishing streams to be considered, not more than ¼ pound should be used. DDT emulsions, and even suspensions, have given good results when applied by aircraft, but most of the work has been done with rather concentrated solutions of DDT in oil. The DDT is first dissolved in xylene or some other excellent solvent, and then this solution is diluted with fuel oil to a concentration of about 10 or 12% DDT. Only a gallon per acre, or less, of the finished solution is required. The oil solution forms a tacky deposit of DDT on the trees, and this tacky deposit seems more effective than the deposit left by powder dispersions. On the other hand, suspensions form larger droplets and less material is carried away by the wind, and suspensions are less toxic to fish. There is still much to be learned, but a lot has already been found out in the short time since the use of DDT against forest insect pests was first started.

FIG. 23. THIS PIG WILL REMAIN FREE FROM FLIES AND LICE FOR A LONG TIME AFTER HER TREATMENT WITH A 5% DDT DISPERSION IN WATER.

(Courtesy of U. S. Dept. of Agriculture. Photo by Madeleine Osborne)

Fig. 24. Cattle on a Florida Ranch are Sprayed with DDT for Control of the Horn Fly.
(Courtesy of Geigy Company, Inc.)

Chapter Six

Old Mother Nature

The Balance of Nature

WE have long been told by those who seem to know that there is a balance, or equilibrium, among the various forms of life on earth. One species of animals eats another, and in turn is eaten by a third. The insects that eat your garden crop fall prey to birds, and birds fall prey to many other animals in addition to your pet cat. We are told of the classical example of Australia, where rabbits introduced by homesteaders soon overran the island continent because there were no foxes or coyotes or other natural enemies of the rabbit to keep the rodents from multiplying at a rate for which rabbits are famous.

So the balance of nature was changed in Australia. And it is constantly undergoing changes everywhere else. The English sparrow and the gypsy moth were not natives of this continent, and when they were introduced into America there had to be a shift in whatever balance of nature existed before. And yet, in spite of the fact that there is nothing static in nature, many alarmists start shouting whenever a new insecticide is introduced, and their cry is always the same: "You will destroy the balance of nature!" To which we can only reply: "What if we do?" There is nothing sacred about the old balance anyway, and if it is shifted there is at least a 50-50 chance that it will be for the better—at least as far as we are concerned. But actually, it's a lot harder to shift the balance of nature than many people assume. Your potato patch may be free from bugs today, but stop spraying or dusting and see how it is in a few weeks. The bugs will be back by the millions—their numbers seemingly unaffected by the temporary setback caused by your spray gun.

One thing that many folks worry about is the fact that DDT kills beneficial and harmless insects as well as those that cause us trouble. There is always the possibility that we may kill off more of the good bugs than the bad ones, and thus do more harm than good. But the chances of this happening are not very great. Even if every insect in a large forest area were killed, the area would be completely repopulated within a few weeks or months, as swarms of insects of every description moved in from the surrounding areas.

Of course, if all the insects on a whole continent could be killed, it would be interesting to see what would happen. But that we shall never see! In the first place, to treat a whole continent with DDT would cost a little money. The United States occupies about 2 billion acres of the earth's surface. Assuming a cost of $1.50 per acre for material and labor, it would cost about 3 billion dollars to spray the whole United States with DDT. Once upon a time this would have been considered out of the question. But not today! Not long ago this country granted Great Britain a so-called "loan" of 3¾ billion dollars, and during the war, between 2 and 3 billion were spent on the development of the atomic bomb. But even if, in some way, we could produce the tremendous quantity of DDT required, and if we could get hold of the money, we probably would be disappointed with the results. In the first place, even if we killed off all of the insects in the United States, we would soon find billions of insect immigrants entering this country from Canada and Mexico. But, of even greater importance is the fact that we could not kill all the insects. Some species are quite resistant to DDT and would survive the attack; and even among those species that are readily killed, a few individuals are bound to escape. And even if 99% of the insects of a certain species were killed, it would not take long for the remaining 1% to re-establish the species on a large scale.

The Busy Bee

From the movies, the radio, the newspapers, and the pulp magazines, our children learn the facts of life at an early age. To an older generation, the sweet little story of the busy bees carrying pollen from the papa flowers to the mamma flowers was the approved method of introducing a child to the mysteries of sex. Actually, however, the child who listened patiently to this roundabout explanation undoubtedly learned much more from certain words scrawled upon the sidewalks and walls of outdoor toilets.

And how often have we been told to follow the example of the bee and keep busy all the time? That's bad advice! The bee may keep busy buzzing around all day, but he doesn't accomplish much for his efforts; and in that respect he isn't much different from the supposedly more intelligent human beings. But all this is beside the point.

Although a bee's sting is a very unpleasant experience, we must admit that bees are useful insects. We are all familiar with the product of the honeybee, and we wouldn't want anything to happen to the production of this delectable confection. But of even greater importance is the role of the bee in the pollination of fruits, as mentioned above. It is easy to understand, therefore, why many orchardists became worried when DDT first came into use. What's to be gained if you kill off insects that attack the trees and at the same time kill the bees that are so essential for pollination? You can't blame our fruit growers for being worried, for laboratory tests showed that DDT will kill bees.

Yet, like many another dire prediction, the fear that DDT used on fruit and field crops would have a disastrous effect on bees has been proved to be unfounded. Actually, DDT is less toxic to bees than the arsenic sprays that have been used for many years. Thus, the substitution of DDT for arsenicals is actually to the beekeepers' advantage. But the case for DDT is even much stronger than that.

Many large-scale experiments have been carried out in which DDT was dusted on fields adjacent to colonies of honeybees. It was found that the number of dead bees was no greater than normal. It is true that very few bees will be found in the treated fields for several days after the application of DDT, but they soon return in normal numbers. Apparently, the DDT merely repels them for some time. This should not be interpreted to mean that DDT does not kill bees, for it certainly does. If bees are actually hit by a DDT spray or dust, they will, in all probability, be killed. But in the concentrations used in most agricultural applications, there is not likely to be enough of a residual deposit to cause the death of bees that later enter the treated area. This has been verified by examining the dead bees around the hives.

Insects that come in contact with residual DDT deposits do not die immediately. Bees, for example, would have sufficient time to return to the hive before passing out. If they did that, it would be very unfortunate, for in that way they could carry DDT to the hive itself and bring about the death of the whole colony. But so far, at least, there is no evidence that bees pick up lethal doses of DDT and return to the hives to die. Either they don't get enough DDT to kill them, or else they get so much that they die right away; and there is no evidence whatever that the latter is the case.

Obviously, one must use judgment when applying DDT to his crops, the same as he does when he uses it in his home. It would not be sensible to spray the blossoms of fruit trees when you knew that the bees would soon be on those very blossoms. The sensible thing would be to spray the trees before the blossoms opened—and no bees were around—and again after the bees had finished their task. Then there would be no possibility of leaving a residual deposit of DDT on the blossoms themselves.

By the proper application of DDT, our bee population should be materially increased, for when destructive insects get in their work, plants are often so badly destroyed that they have few blossoms and, hence, little food for bees. Thus, treatment of alfalfa fields with DDT before bloom is very desirable from the bee's point of view as well as from the farmer's. The results can be summarized in a few words: Fewer insects, more flower buds, more bees, better pollination, and more seed.

Bees have been with us a long, long time. They have seen many insecticides come into use, and they will undoubtedly see many more. So far, no insecticide has seriously affected our bee population, and DDT is less likely to do this than other popular insecticides. Your chances of getting stung by a bee a year from now will, undoubtedly, be every bit as good as they are today.

Tougher Bugs

In the age-old battle between men and insects, man has devoted his efforts to new and better ways to kill, and the insects have retaliated not only by an all-out breeding program, but also by breeding tougher individuals. This goes back to Darwin's idea of the survival of the fittest. When we use an insecticide, the more susceptible individuals are killed off, but some of the real tough babies survive, and their offspring, according to the universal law of heredity, are tough like their parents.

This is very disturbing. And it is probably even more disturbing in the field of medicine than it is in the field of insecticides. Penicillin, a few years ago, was the "wonder drug"—cases of gonorrhea, certain types of pneumonia, and many other diseases were cleared up in a short time when penicillin was brought into the battle. But before long something began to happen: many diseases were no longer responding to penicillin treatment the way they formerly did. What was happening? Seemingly, the good old law of the survival of the fittest. Penicillin killed a lot of germs, but a small percentage of germs were not killed, and from these penicillin-resistant individuals, new and tougher strains were developing.

Pencillin is not the only drug with which this phenomenon has been noticed. The sulfa drugs, remarkably effective at first, began to lose their effectiveness as sulfa-resisting strains developed from the germs that survived sulfa treatment. This, undoubtedly, has happened with all of man's germ killers. The battle never ends. A new drug is developed and proves effective for a while. But then strains of germs resistant to that drug evolve, and a new drug must be found. Who will win the battle—man or germs? It is still anyone's guess. Perhaps with our more-or-less indiscriminate use of drugs we are merely accelerating the development of tougher and tougher strains of germs—strains which will prove resistant to any of our drugs.

Will the use of DDT result in the development of tougher insects? Will the flies and mosquitoes of tomorrow walk over a DDT-covered surface or fly through a mist of DDT spray with no ill effects? We'll just have to wait and see.

Chapter Seven

The End of the Story

What Next?

AND there it is—DDT—one of the newest, and certainly one of the most important of the insect killers that man has developed for use against his insect enemies. Is it the final weapon—the weapon that will win the war for mankind? Certainly not! No one claims that it is! Against many insects it is ineffective. Against many others it is less effective than other insecticides already in use. But against many of our obnoxious insect enemies it is the most effective substance yet developed. When properly formulated and applied, DDT will protect man against lice, his dog against fleas and ticks, his cattle against flies, and his crops and trees against a variety of insects that crawl and fly; it will rid his home of flies and mosquitoes; and it will keep his bed free from bedbugs. Yes, it will do all of these things—and it will do many more.

But, does this mean that with the advent of DDT these insects are doomed to extinction? Can man look forward to an insect-free world? Hardly! Insects have existed for millions of years, and they have shown remarkable ability to adjust themselves to new conditions. Otherwise they could not have survived. The development of new poisons for the control of insects is usually followed shortly thereafter by the appearance of more resistant strains. And when certain insects are driven from a locality, others, perhaps even new species, come in to take their place.

The early, over-optimistic pictures painted by some of the more sensational journalists when DDT first made its appearance were often based on wishful thinking, not upon facts. Because beachheads could be freed from mosquitoes before the landing of troops, and practically all insect life could be killed on small Pacific islands, people began to dream of an insect-free world. One large area after another was treated with DDT and trillions of insects—both good and bad—perished in this mass experimentation. Yet, the insects came back. Intoxicating hopes gave way to a depressing morning-after feeling. Those who were most loud in their heralding of the "Miracle" insecticide, were the first to swing in the opposite direction and belittle the value of the material whose praises they had formerly sung.

Thus again, we saw a repetition of the common cycle of events that has accompanied the discovery of every cure for the ills of mankind. A few years ago sulfa drugs were hailed as the wonder healers for which the world had so long been waiting. These drugs were to wipe out all of the diseases of man—at least according to the words of many uninformed prophets. And then came penicillin to capture the headlines of our papers and the hopes of the ill. Then came other drugs, such as gramacidin and streptomycin—and still the magic cure-all remains to be found. All of these drugs have certain uses and all have certain limitations. The men who knew most about them were most conservative in their predictions. They were not responsible for the many rash statements that the public so easily swallowed.

It is the same with DDT. Yes, it is a magic killer! But it is not the silver bullet which will put an end to all insect life—if that were desirable. And, as in the case of the medicinals, those who had the most to do with the development of DDT insecticides were not the ones who made the fantastic claims.

Let us evaluate DDT on the basis of what it has done and what it can do—not on what somebody hoped it would do. When we take this rational point of view we are led, inevitably, to the conclusion that the development of DDT was the greatest contribution to the field of insecticides since that day in 1869 when man first began to use poisons in his fight against his eternal enemies—the enemies that fly, that crawl, and that hop; and yet are so small that it is hard for us to believe that some day they may, if we weaken our guard, inherit the earth.

Appendix

FOR those of you who are too lazy to read what we have said in the first part of this book and want to get information the easy way, we have added a few pages to give you, in condensed form, instructions on how to use DDT for the control of the common insect pests that affect man and animals.

And for the benefit of gardeners, farmers, foresters, and nature-lovers in general, we have included information on how to use DDT to control the more common insect pests that affect agricultural crops and forest and shade trees.

We realize that the second part of the Appendix is not as extensive as it might be, and we don't want you tillers of the soil to feel that we have slighted you. The reason that this section is not longer is due merely to the fact that DDT is so new that our agriculturists have not had time to make the extensive tests that are necessary before an insecticide can be recommended for all the uses to which it can probably be put. Perhaps at some later date we may be able to bring you the whole story, but for the time being this will have to do.

Part I

Instructions for the use of DDT in the control of the common insect pests that affect man and animals.

ANTS

For the control of ants in buildings, apply a 5% DDT solution, by spray or brush, behind and beneath baseboards, window sills and frames; around sinks, and table and chair legs; to both sides of pantry shelves; and to cracks and crevices leading to the outside of the building. If the ants travel along well-defined trails, pay particular attention to these areas. A 10% powder is also effective, but is usually more difficult to apply and, of course, leaves a visible deposit. However, the powder is very effective when applied directly to ant hills. Ants will usually abandon an ant hill within a short time after a small amount of DDT powder is applied around the entrance holes.

A single application of the spray or powder will control many species of ants for several weeks. However, some species do not respond to the DDT treatment. In such cases, the addition of 1/10% pyrethrins to the 10% powder often proves effective.

BEDBUGS

DDT is the perfect answer to bedbug control. Three fluid ounces of 5% DDT in deodorized kerosene, used as a spray, or about 2 oz. avdp. of a 10% DDT powder will not only kill all the bedbugs in a full-sized bed, but will prevent re-infestation for at least 6 months. The spray or powder should be applied to both sides of the mattresses and pillows, to the bed springs, and to the cracks and joints in the bedsteads. Furthermore, since bedbugs may hide behind pictures on walls, and in cracks and crevices along the window and door frames and along baseboards and mouldings, these places should also be sprayed or dusted. When the spray is used, the bed should be permitted to dry for a few hours before it is made up. Neither the DDT dust nor the DDT deposit left after the evaporation of the solvent from a spray will harm the skin.

CARPET BEETLES

For the control of carpet beetles in carpets, rugs, and upholstered furniture, treat with a 5% DDT solution in the same manner as described for the control of clothes moths.

CLOTHES MOTHS

(*See* MOTHS)

COCKROACHES

DDT is effective for the control of the American cockroach, the German cockroach, and the brown-banded roach. Either 5% DDT in kerosene or in emulsion form or a 10% DDT powder can be used for the control of these insects. With either material, it is necessary to maintain an effective residual deposit. To kill roaches as they come into the building from the outside, or as they migrate from one part of the building to another, apply the spray or powder to their hiding places—around refrigerators and sinks; pantry shelves, table tops, table and cupboard drawers, and pipe openings; and along baseboards, cracks, mouldings, etc. Since cockroaches like to walk upside down beneath refrigerators, shelves, and table tops, it is a good idea to spray these places thoroughly.

The action of DDT on roaches is slow, but it eradicates an infestation in about a week after application if the DDT residue is not removed.

FIREBRATS

(*See* SILVERFISH AND FIREBRATS)

FLEAS

For fleas on dogs, dust a 10% DDT powder thoroughly into the hair of the animal, along the back from the head to the tail. About 1 tablespoon of powder is sufficient for the average-sized dog. For perhaps an hour after application, fleas will probably show greater activity with resultant greater discomfort to the animal; however, the fleas begin to die in about 10 minutes, and after a few hours none are left. A single treatment is sufficient to protect dogs from further infestation for several days.

In addition to dusting the animal, treat the sleeping places of the dog, and infested basements and rat burrows with about ½ lb. of 10% DDT powder or ½ gallon of 5% DDT solution per 1,000 square feet of floor space.

For flea-infested floors, rugs, overstuffed furniture, and fabrics, a light application of about 1 gallon of 5% DDT in kerosene per 4,000 square feet of surface is not only effective against the fleas themselves but also against the flea larvae. A 5% DDT emulsion or a 2½% DDT suspension of wettable powder can be used in place of the kerosene spray where staining and the white residue are not objectionable. DDT suspensions are particularly advantageous for use on flea-infested lawns, where kerosene might damage the grass.

For the control of fleas on cats, DDT powder should not be applied directly to the animal since cats lick themselves and might ingest sufficient DDT to make them sick. However, treatment of the sleeping places of cats and other flea-infested areas, as described above, is very effective for controlling fleas.

FLIES

In Buildings

Space sprays with as little as ¼% DDT, together with pyrethrum or organic thiocyanates for rapid knockdown, will kill all flies that are hit by the spray mist.

Aerosols containing 3% DDT and 2% pyrethrum ex tract are very effective space sprays. The extremely fine mist that is evolved while the trigger is depressed remains in suspension for a considerable period of time and is carried to all parts of the room.

Residual sprays containing 5% DDT in deodorized kerosene are used where long-lasting action is desired. These sprays are applied to the walls and ceilings, screen doors, lamp cords, and other surfaces on which insects light. An invisible deposit of DDT remains after the evaporation of the solvent, and any insects that come in contact with it are doomed, although they may continue to live for an hour or more. The spray should be applied at the rate of 1 quart for every 250 square feet of surface. One application will remain effective for long periods of time—from a few weeks in exposed places up to several months in enclosed areas.

Emulsifiable solutions of 25 or 30% DDT can also be used where residual action is desired. These solutions are mixed with water before use to provide an emulsion of 5% DDT. These emulsions, however, should not be used where water might stain the surface or where the white deposit is unsightly. For use in barns and other outbuildings where staining and appearance are not factors that have to be considered, emulsions are desirable since they eliminate the fire hazard associated with an oil spray.

Wettable powders containing up to 50% DDT mixed with pyrophyllite make effective residual sprays for barns and other outbuildings where one doesn't mind the white deposit on the walls. For use, sufficient powder is added to water to give a 2½% DDT mixture. A 5% mixture is not needed because the powder, unlike the oil solutions and emulsions, does not penetrate into porous surfaces. About 1 gallon of the 2½% spray should be used for approximately 300 square feet of surface.

Paints containing up to 6% DDT are available, and can be used where residual action is desired. They afford protection for approximately the same length of time as the usual types of residual sprays.

On Cattle and Horses

For the control of houseflies, stable flies, and horn flies on cattle or horses use a 2½% DDT emulsion or dispersion of wettable powder. Apply the spray at the rate of about 1 quart per adult animal, paying particular attention to the belly, rump, and back. A single application should effectively control the flies for at least 2 weeks. An alternative method is to dip the animal in an emulsion of about ¼% DDT. On the average, about 2 gallons are required for each adult animal.

HORNETS

(*See* WASPS AND HORNETS)

LICE

On Humans

There are three types of lice that affect humans: body lice, head lice, and crab, or pubic, lice. DDT is effective against all three types.

For the body louse, apply 1 ounce of 10% DDT powder to the inner surface of underclothing and another ½ ounce to the seams of the outer garments. A single application will completely eradicate the lice, and if left in the clothing the powder will continue to kill lice for several months.

For the head louse, thoroughly shake a 10% DDT powder into the hair. It will kill all lice but will not kill the eggs, or nits. Since it takes several days for the eggs to hatch, the DDT powder should be left in the hair for at least 10 days in order to kill the young lice as they hatch from the eggs. An alternative method is to make two applications of the DDT powder about 8 to 10 days apart. It is advisable to let each application remain for about 24 hours before washing the hair. The second application will kill lice that have hatched since the first application was made.

In order to get rid of head lice in a hurry, the NBIN formula can be used since it kills the eggs as well as the adult lice. This material is applied to the hair in the form of an emulsion made up of 5 parts of water and 1 part of a concentrate consisting of 68 parts of benzyl benzoate, 12 parts of benzocaine, 6 parts of DDT, and 14 parts of a dispersing agent. The hair should be thoroughly wetted with the emulsion, combed to insure uniform distribution, and then permitted to dry. It is unnoticeable in the hair, and should be left on for 8 to 10 days in order to kill any lice that may have been hiding in the clothing and ultimately return to the head.

The crab, or pubic, louse can also be killed with either a 10% DDT powder or an emulsion of the NBIN formula.

In either case, the material should be applied to all hairy portions of the body, including the arm pits, chest, the pubic and perineal region, and the legs, and should be thoroughly rubbed in with the fingers. A single application of the NBIN formula, left on for 24 hours in order to catch any lice that have been hiding out in the bedding or clothing, will completely eradicate the infestation. If the powder is used, it should be left on for 24 hours before one takes a bath, and a second application should be made in about 8 or 10 days.

On Cattle

Apply 10% DDT powder to infested cattle, either by dusting or by rubbing the powder into the coat by hand. Pay particular attention to the neck, ears, head, shoulders, withers, tail base, and inner leg surfaces. An alternative method, which is particularly advantageous when a large number of animals are to be treated, is to dip the animals in an emulsion or dispersion of about ⅕% DDT in water. Emulsions are readily prepared from solutions of 25 or 30% DDT in soluble pine oil or other solvent, and dispersions are easily made by adding about 30 pounds of 50% DDT wettable powder to 1,000 gallons of water.

On Goats, Hogs, etc.

A ⅕% DDT dip, as described above, will satisfactorily control lice on goats, hogs, and other animals as well as on cattle.

On Poultry

Dust either a 5 or 10% DDT powder well into the feathers of the birds, getting it down to or near the skin surface. Pay particular attention to the head and neck, underneath the wings, and below the vent.

MOSQUITOES

In Homes

Mosquitoes in homes can be killed with the same DDT formulations that are used against flies. Space sprays can be used to kill the mosquitoes present at a given time, or residual sprays—oil sprays, emulsions, or dispersions of wettable powders—can be used to kill mosquitoes that venture around the premises over a period of months.

Around Premises

To cut down the mosquito population, it is also a good idea to either spray the lawn and shrubbery around the house with a 2½ or 5% DDT emulsion or dispersion, or to sprinkle them with a 5 or 10% DDT powder.

In Breeding Grounds

For effective mosquito control, the breeding grounds should be treated with about ⅒ pound of DDT per acre. The DDT can be applied in the form of a kerosene or other oil solution, as an emulsion, or as a dispersion of wettable powder in water. For large areas of swampland or vegetation, application by airplane is very effective. For stagnant waters, 1 part of DDT per 100,000,000 parts of water will kill the larvae of most species of mosquitoes.

MOTHS

In Clothes

DDT is very effective against both the adult moth and the larvae. One application protects clothes from moths for several months if the residue is not removed by dry cleaning. For application to clothes and upholstery, 5% DDT in deodorized kerosene may be used, but a more volatile solvent such as dry-cleaner's solvent (Stoddard solvent) is preferable.

For clothes hanging in closets, spray the garments liberally, paying particular attention to the seams and folds, and also apply a thorough deposit to the closet walls, ceiling, and floors, and especially to cracks and openings around the baseboard.

In Stored Woolens

For woolens that are to be stored in chests, first spray the chest thoroughly with a 5% DDT solution, and then spray each garment as it is put away. Apply the spray to all surfaces of the goods, paying particular attention to seams and folds.

In Carpets, Rugs, and Upholstered Furniture

For carpets, rugs, and upholstered furniture, spray the surfaces of the articles liberally with a 5% DDT solution. In the case of upholstered furniture, also either inject a spray needle into the furniture padding so as to obtain more effective application, or else remove the backing and spray the padding. This treatment will also protect rugs, carpets, and upholstered furniture against carpet beetles.

SILVERFISH AND FIREBRATS

Treat the breeding places of these insects with 5% DDT solution or 10% powder. Likely areas are behind loose wall paper and in or near bookcases, and particularly in basements near furnaces and other warm locations.

TERMITES

Treat the soil around the timbers that are to be protected with a 5% DDT-kerosene solution. One treatment will remain effective for at least two seasons.

TICKS

Brown Dog Tick

About the only tick found in large numbers in homes is the brown dog tick. This tick hides in cracks and crevices about baseboards, and in floor coverings. After getting their meal of blood from dogs or other animals, the ticks return to their hiding places.

Treatment of dogs and the building premises with 10% DDT powder for eradication of fleas, as described previously, will effectively control this tick. However, DDT kills the tick slowly, and powder sprinkled around the floors should be permitted to remain for about 2 weeks. Although it cannot be used on the animals themselves, a 5% DDT-kerosene spray is very effective against the brown dog tick when applied to walls, floors, rugs and other hiding places of the insect.

Fowl Ticks

Poultry houses infested with fowl ticks can be successfully treated with 5% DDT in kerosene. The perch poles, cracks and crevices, behind and beneath nesting boxes, and other potential hiding places of the tick should be thoroughly sprayed. A single application will keep the poultry house free from ticks for 3 months or longer, and at the same time will eradicate poultry mites. Obviously, to avoid any possible injury to the poultry, spraying should be done when the birds are not in the house.

American Dog Tick

This tick, which can transmit the eastern strain of spotted fever, is often found in parks, camp sites, and on the premises of residences. It can be controlled by applying a ½% DDT emulsion at the rate of about 3 pounds of DDT per acre.

WASPS AND HORNETS

These insects are killed readily by DDT. Spray their nests with 5% DDT solution or dust them with 10% powder, and the wasps or hornets will abandon their nests within a very short time.

Part II

Instructions for the use of DDT on vegetables, flowers, and shade and forest trees.

ALFALFA

Lygus Bug Control

Apply, just before bloom, a 5% DDT-sulfur dust at the rate of 30-40 pounds per acre, or a 10% DDT dust at the rate of 15-20 pounds per acre.

BEANS

Leaf Hopper and Leaf Roller Control

Apply a 3% DDT dust at the rate of 30-40 pounds per acre every 2 or 3 weeks before the pods are formed.

CABBAGE

Cabbage Worm, Cabbage Looper, and Diamond-Back Moth Control

Apply a 2 or 3% DDT dust at the rate of 20-30 pounds per acre every 2 or 3 weeks before the heads form, or apply 150 gal. per acre of a spray prepared from 1 pound of 50% DDT wettable powder per 100 gal. of water. Make the first spraying a week or 10 days after the plants are set; the second application 2 to 3 weeks later as needed; and the third application about the time the heads start to form.

Do not apply DDT for 30 days before cabbage is to be ready for market.

CITRUS FRUITS

Thrip Control

Apply a 3% DDT-sulfur dust at the rate of 125-150 pounds per acre when infestation occurs, or apply 100 gal.

per acre of a spray prepared from 4 pounds of 50% DDT wettable powder per 100 gal. of water.

CORN

European Corn Borer Control

Use either a 3% DDT dust or a spray prepared from DDT wettable powder. The 3% dust is applied at the rate of 30-40 pounds per acre at weekly intervals just before the tassels emerge. The spray is prepared from 1 pound of 50% DDT powder per 100 gal. of water, and is applied at the rate of 150-200 gal. per acre. Three to five applications should be made at 5- to 7-day intervals.

COTTON

Boll Worm Control

Apply a 5% DDT dust at the rate of 15-20 pounds per acre as soon as the moths begin laying eggs. Make 2 or 3 applications at 5-day intervals.

Flea Hopper and Lygus Bug Control

Apply a 5% DDT-sulfur dust at the rate of 25 pounds per acre as soon as infestation appears.

FLOWERS

Thrip and Aphid Control

DDT gives very good control of thrips and aphids on snapdragons, chrysanthemums, and roses. A satisfactory spray can be prepared by adding 1 to 2 pints of 25% DDT emulsifiable solution to 100 gallons of water. Application should be made about every 2 or 3 weeks, or as often as the insects reappear.

FOREST TREES

(*See* TREES)

GRAPES

Leaf Hopper Control

Apply a straight 3% DDT dust or a 3% DDT-sulfur dust at the rate of 20-30 pounds per acre before the fruit sets. An alternative procedure is to use an atomized oil spray consisting of 1-2% DDT in kerosene or mineral seal oil. The spray should be applied at the rate of 2-4 gal. per acre as soon as the leaf hopper appears and before the fruit has set.

ONIONS

Thrip Control

Use either a 3% DDT dust or a spray of DDT wettable powder. Apply the dust at the rate of 45-50 pounds per acre at the first sign of thrip damage, and repeat this treatment at 14-day intervals as needed. Prepare the spray by using 1 to 2 pounds of 50% DDT wettable powder per 100 gal. of water, and apply at the rate of 200 gal. per acre. Make 2 or 3 applications at intervals of 10-14 days apart after thrips appear.

PEAS

Aphid Control

Apply a 4 or 5% DDT dust at the rate of 35-40 pounds per acre when aphids begin to appear in numbers.

Weevil Control

Apply 5% DDT dust at the rate of about 20 pounds per acre after weevils appear but before the pods are formed.

POTATOES

Colorado Potato Beetle Control

Apply a 2 or 3% DDT dust, with or without fungicides, at the rate of 20-30 pounds per acre when the plants are 6 to 8 inches high, or apply a spray made from 1 pound of 50% DDT wettable powder per 100 gal. of water at the rate of 100-150 gal. per acre.

Leaf Hopper and Potato Flea Beetle Control

Apply a 3% DDT-copper dust at the rate of 30-40 pounds per acre as soon as the pests appear, and repeat at 10- to 14-day intervals as needed. Or, spray with a suspension prepared from 2 pounds of 50% DDT wettable powder per 100 gal. of water.

Psyllid and Tuber Flea Beetle Control

Use a 5% DDT-sulfur dust at the rate of 20 pounds per acre, or a 3% DDT dust at the rate of 35-40 pounds per acre as soon as insects appear, and repeat every 10-14 days as needed. A spray prepared from 2 pounds of 50% DDT wettable powder per 100 gal. of water can also be used.

Aphid Control

Apply a 5% DDT-copper dust at the rate of 40-45 pounds per acre every 10 days starting with the first appearance of the aphids.

SHADE TREES

(*See* TREES)

SUGAR BEETS GROWN FOR SEED

Lygus Bug Control

Apply a 5% DDT-sulfur dust at the rate of 30-40 pounds per acre, or a 10% DDT dust at the rate of 15-20 pounds per acre.

TREES

Shade Trees

Apply a 1/10% emulsion with a hand knapsack or power sprayer until the spray material begins to run from the surfaces of the leaves. This will give excellent control against defoliating insects, such as the gypsy moth, elm leaf beetle, catalpa caterpillar, locust leaf miner, boxwood leaf miner, canker worm, sawfly, evergreen bagworm, tent caterpillar, and many others.

Forest Trees

Defoliating insects on forest trees can be controlled in the same manner as described above for shade trees, but this method is satisfactory for only relatively small areas. For large tracts of forest lands, the only practical method is to spray the area from an airplane.

The quantity of DDT required is usually from about ¼ to 1 pound per acre. Since fish are much more susceptible to DDT poisoning than are warm-blooded animals, the amount of DDT applied over areas containing fishing streams should not exceed ¼ pound per acre.

The DDT can be applied in the form of an emulsion or as a dispersion of wettable powder, but the most common spray solution is prepared by dissolving DDT in xylene and diluting this solution with fuel oil to a concentration of about 10 or 12% DDT.

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