CHAPTER 6

WORLD WAR II AND THE AXIS OF DISEASE

Battling Malaria in Twentieth-Century Italy

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In the summer of 1943 Allied troops began their invasion of southern Italy, and by April of 1945, the countryside from Sicily to the Roman Campagna was pockmarked by craters from bomb shells and artillery. This scarred landscape, along with villages and cities devastated by battle, became an ideal habitat for rodents and insects and perfect breeding grounds for mosquitoes. Soldiers and civilians across the peninsula were contracting typhus, tuberculosis, dysentery, and especially malaria, with many of these ills being spread by the vermin and parasites who were the immediate victors of every battle. As the dust settled and the front moved northward, villages such as Castel Volturno (which lies north of Naples) and then the Tiber Delta became the first places in Europe where health officials would experiment with dichloro-diphenyl-trichloroethane, or DDT, as a means to kill mosquitoes and thus control the spread of malaria (map 6.1). The next spring, following heavy winter rains, spray crews and airplane dusters began fumigating the soggy, war-torn countryside, testing out the miracle insecticide that had already proved itself so effective in the South Pacific. Warfare disrupted the ecosystems that kept malaria in check, but it also led to the development of new technologies that might enable eradication of this disease. In this Italian case of war and environment, I offer examples of how malaria modified combat and its outcomes, as well as examples of how warfare modified malaria. As we ponder other wars—past, present, and future—it behooves us to consider the multiple, though seldom-studied effects of linking belligerent humans with infectious microbes.

6.1 Map of Sardinia, created by David Wilson, Center for Instruction and Research Technology, University of North Florida.

Causes and Effects of Malaria

Soldiers have always shared their battlefields with disease. The chaos and unsanitary conditions that characterize every combat zone, combined with soldiers' lowered resistance to pathogens of all kinds, have meant that invading armies often tallied more losses from bugs than from bullets. Napoleon learned these facts of war through his defeat at Waterloo, where typhus disabled twice as many men as enemy fire. During the U.S. Civil War, one source claims that 1.2 million soldiers contracted malaria, with eight thousand of them succumbing to the disease. Gen. Douglas MacArthur understood the potential threat that an outbreak of malaria posed to U.S. troops in World War II when, midway through America's Pacific campaign, he told Army medical experts, "this will be a long war if for every division I have facing the enemy I must count on a second division in the hospital with malaria and a third division convalescing from this debilitating disease!" Within a few months of their July 1943 landing in Sicily, more than twenty-one thousand American and British soldiers had been hospitalized with malaria, surpassing in numbers their seventeen thousand comrades who had been wounded in battle. If it was bad strategy for the Germans to invade Russia in winter, it was also bad strategy for the Allies to storm Italy's pestilential coasts in summer.[1]

Italian officials kept careful watch over their nation's health. Infectious dis-

eases such as malaria were considered impediments to progress, and Mussolini's ambitious program of Bonifica Integrale (a kind of Italian New Deal) included massive land-drainage programs that were meant to improve agricultural capacity as well as public health. Malaria was endemic to most of the peninsula's coastal marshes, and the drainage of these wetlands was seen as a crucial step toward the achievement of Italy's productive potential. Auspiciously, statistics like those compiled in the early 1960s by malariologist Alberto Coluzzi suggested that Italy was indeed winning its battle with malaria. According to his figures, which cover the sixty-three-year period from 1887 to 1950, the main deviations from the steady downward trend in malaria morbidity were the years of the two world wars. His graph shows a strong correlation between military conflict and increased risk of death from malaria (figure 6.1).[2]

Before pointing to the probable mechanisms by which warfare promoted malaria, one should realize that malaria statistics require interpretation. Variously termed *mal-aria* (bad air), *le febbre* (the fevers), and *paludismo* (swamp disease), the disease manifested itself in numerous ways and was hard to diagnose positively without specialized tests and equipment. Lacking access to laboratories in which the malaria parasite, or plasmodium, could be identified in a patient's blood sample, most country doctors in the first half of the twentieth century simply noted symptoms and palpated the patient's spleen—and then assumed that more distended spleens indicated greater malarial infection. Variable symptoms of the disease, ranging from fever and lethargy to nausea and chills, also made it difficult to single out malaria as the sole cause of sickness or death. In fact, plenty of *carriers* of the malaria plasmodium suffered few or no ill effects—physical or physiological—so that measuring *incidence* of malaria was especially difficult. Many health officials nonetheless trumpeted Italy's malaria declines, drafting downward sloping curves of malaria incidence that paralleled those of malaria mortality—with both curves showing wartime increases in malaria. Yet incidence numbers, like mortality rates, suggested a degree of certainty unsupported by the data.

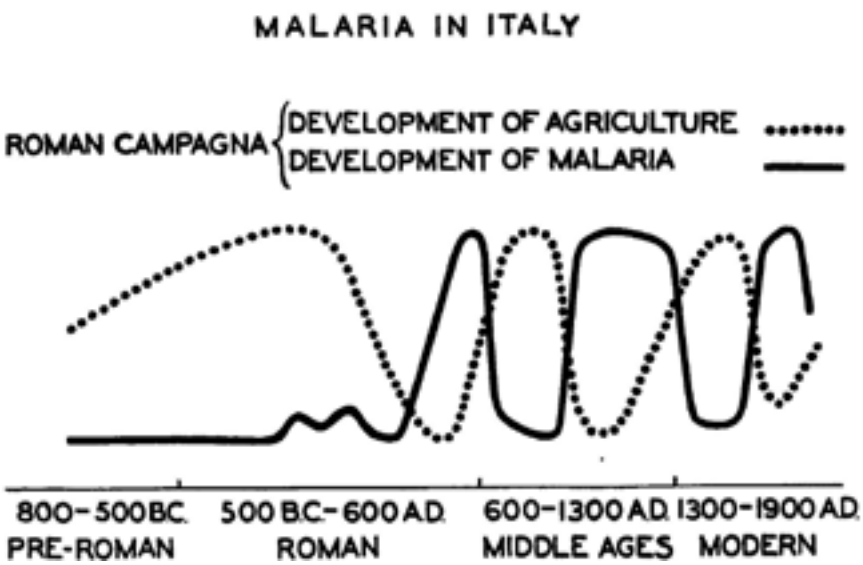
Alberto Missiroli, one of Italy's leading malariologists during the war years, speculated even more widely when linking malaria rates to societal unrest. Offering a *longue durée* view of the Roman Campagna that reached across the twenty centuries since Christ's birth, Missiroli produced a graph that represented acute malaria with a line of three peaks that were mirrored by another line showing three agricultural declines. In the text accompanying this graph, Missiroli suggested that severe malaria foretold periods of agricultural disruption and social struggle, with these cycles recurring three times over the past two millennia. In its 1946 annual report the Rockefeller Foundation reproduced Missiroli's graph to help justify its ongoing investment in Italy's health-care system. Since the early 1920s the foundation had helped to finance Rome's new health institute, the Istituto Superiore di Sanità, and it was continuing to provide expertise and monies that would culminate in its heavily

6.1 Mortality from malaria in Italy from 1887 (the year in which national statistics began to be kept) to 1950, reproduced from Alberto Coluzzi, "L'eradicazione della malaria: Una sfida al mondo," Annali della Sanità Pubblica *22, no. 2 (1961): 241–53.*

sponsored Sardinia Project, a massive postwar malaria-eradication effort. In reproducing Missiroli's graph, the Rockefeller Foundation was implying that the elimination of malaria would promote peace and accelerate economic development. But, on second view, this graph could just as easily be implying that promoting peace and development would rid malaria from the land. Was malaria a cause or an effect of social disruption, regional conflict, and warfare (figure 6.2)?[3]

An initial consideration of this question suggests that there is much more evidence to support the second proposal, namely that warfare exacerbated malaria. Not only did the water-filled bomb craters and tank tracks that zigzagged across Castel Volturno's countryside serve as mosquito breeding grounds, thus accelerating malaria transmission, but also a scattering of stagnant puddles could have large multiplier effects on mosquito populations. In malaria-control programs since the early 1900s, whether in temperate or tropical climes, even open water wells and the occasional pail or can of standing rainwater were scrupulously covered, or else sprayed with diesel oil to hinder the growth of mosquito larvae. Because a mosquito's maximum flying range is only one or two miles, the close proximity of battlefield puddles to human dwellings could play an important role in the spread of malaria. The adage that "malaria fled the plow" may have arisen through observing that malaria rates declined when farmers began draining swamps and leveling the land for growing their crops.

Yet just as war's environmental disruptions created opportunities for malaria



6.2 The interrelationship between agricultural development and the incidence of malaria in Italy from pre-Roman to modern times, reproduced from Alberto Missiroli, "La Malaria nel 1944 e misure profilattiche previste per il 1945," Rendiconti dell'Istituto Superiore di Sanità *(1944): 639.*

to spread, war's social, political, and infrastructural upheavals also helped to transmit the disease. Critically, sustained battle often resulted in the disintegration of local health-care systems. For example, if hospitals and malaria clinics were not reduced to rubble, they usually lay far from the neediest patients. Antimalarial measures, such as the distribution of free or inexpensive quinine and atabrine, were also hindered by a state of war. These drugs offered a degree of prophylaxis (by protecting people from acquiring the malaria parasite) and of cure (by killing the parasite if contracted). Since 1900, the Italian government had subsidized large-scale, preventive quinine dosing in programs that were often referred to as *bonifica umana,* or human improvement. These quasi-eugenic measures of disease control were considered by their promoters to be one of the reasons why Italy had begun rolling back malaria, except during periods of war.[4]

Warfare also exacerbated malaria in more indirect ways. For example, when soldiers and civilians were forced to sleep in the open air because their dwellings and other forms of shelter were destroyed, they became more susceptible to disease-carrying mosquitoes. War refugees, too, flooding into Italy from Africa and Eastern Europe, many of them carrying the disease, served as reservoirs of the malaria plasmodium that hungry mosquitoes could distribute to the healthy population. World War II also disrupted the free trade of pyrethrum, one of the major insecticides employed for killing mosquitoes; the Japanese-dominated manufacture of pyrethrum from chrysanthemum flow-

ers meant that the Allies found themselves scrambling to identify alternative insecticides.[5]

Some two decades after the Allied invasion of Italy, American malariologist Paul Russell reflected on the various ways by which war encouraged the spread of malaria, noting especially the habitat changes resulting from a war-ravaged landscape, the consequences of a disrupted health-care system, and urban refugees' heightened exposure to mosquitoes in the countryside. Russell, a Rockefeller Foundation health officer who directed the Allied Commission's malaria control efforts, also witnessed the aftermath of sabotaged public works along the Roman coast, where the retreating Nazis flooded fields by destroying irrigation pumps and obstructing drainage canals. When Alberto Missiroli observed that these newly inundated areas were nurturing a local malaria epidemic by the summer of 1944, he judged these coastal landscapes to have regressed to their nineteenth-century conditions. Missiroli warned that war's activities had returned these marshlands to their preindustrial, miasmal state.[6]

A closer reading of the wartime records, however, indicates that the Nazis' destruction of the Tiber delta's pumps is better understood not as sabotage but as biological warfare. The retreating Nazi troops realized that inundating this delta would multiply their enemies' risk of contracting malaria. A half meter of standing water on Rome's coastal plains not only hindered travel by foot and vehicle; it recreated ideal biological conditions for breeding *Anopheles labranchiae,* the local mosquito vector responsible for transmitting the malaria plasmodium.

According to Missiroli's official communications, the German command gave orders on October 9, 1943, to turn off all drainage pumps in the reclaimed Maccarese area of the northern Tiber delta. Over the next two weeks, most other drainage pumps across the remainder of the delta were also stopped, and in some cases, the pumps were actually reversed to begin inundating previously drained areas. Drainage canals were also blocked to promote greater flooding, while key levees were breached to allow saltwater to flow into reclaimed areas; entomologists knew that moderately salty water favored the development of mosquito larvae. In fact, German malaria experts Erich Martini from the University of Hamburg and Ernst Rodenwaldt from the University of Heidelberg had been sent to the delta that autumn to oversee inundation operations. Missiroli reported that by the first of December, 3,000 hectares in the Tiber delta had been submerged, together with another 6,000 hectares in the nearby Agro Pontino to the south. Nazi officials were perfectly cognizant of the malaria problems that their enemy had confronted a few months earlier in Sicily, and with the Allies now pushing at the gates of Rome, the Nazis were hoping that malaria-carrying mosquitoes could again be recruited to their side. No wonder Paul Russell often referred to malaria as the "Plasmodium-arthropod Axis."[7]

For Missiroli the flooding of the Tiber delta represented more than a way to fend off invading armies. Surviving correspondence and a diary suggest that

Missiroli had himself collaborated with the German authorities, not only helping them to properly flood the area but also fostering a malaria epidemic that he realized would be useful for carrying out future investigations of the disease; more patients would allow for more remedies to be tested. Always the scientist, Missiroli saw a newly flooded delta as an excellent laboratory for advancing the field of malariology.

It should be pointed out that Missiroli enjoyed a long working relationship with his German colleague Martini, with whom he had jointly authored scientific papers. Although it is unclear whether Missiroli or Martini was the first to call attention to the investigative advantages of flooding the Tiber delta, by late August of 1943, Missiroli was already suggesting to the Maccarese Reclamation Company that his own Laboratory of Parasitology be put in charge of the area's malaria-control efforts. Six weeks later the Maccarese area's main drainage pumps were turned off, and shortly thereafter Missiroli fired all but two of the personnel responsible for carrying out mosquito-control operations. In mid-November, Missiroli toured the flooded regions with Martini; together they recommended that the pumps remain turned off for "scopi bellici"—military reasons—while cautioning Italian health authorities to prepare for the coming malaria season. Another of Missiroli's colleagues, Alberto Coluzzi, would note in his diary that Missiroli helped to mastermind the Maccarese flooding.[8]

That next summer, after the June arrival of Allied troops in Rome and nearly a year after the Italian government's official surrender on September 8, 1943, Missiroli was blaming the Germans for the flooding and the resulting malaria epidemic. While he proposed that the Allies begin fitting the delta's houses with mosquito screening, he was much more interested in trying out the newly discovered insecticide dichloro-diphenyl-trichloroethane. In fact, so intent was he on testing out DDT that he decided to temporarily suspend all distribution of antimalarial drugs in the Maccarese. He reasoned that medications such as atabrine could quickly resolve that season's rising malaria problem, but to distribute them would make it difficult to interpret the efficacy of DDT spraying. Missiroli rationalized his experimental priorities by explaining that most of the new malaria cases arising in the Maccarese would be of the relatively innocuous third-order type—at least initially—and so could be ignored when designing DDT studies. Unfortunately for many residents of the delta, Missiroli's experiments also required that several other areas remain unsprayed and that their inhabitants remain untreated to serve as controls. In these unsprayed areas and untreated control populations malaria would temporarily "assume vast proportions" over the next twelve months.[9]

It should also be pointed out that Missiroli came from a long tradition of experimental malariology that sacrificed the needs of the few for the potential benefit of the many. Missiroli's laboratory had carried out other investigations in malaria-infested regions of Calabria and Sardinia, whereby recognized malaria remedies were withheld for testing a new procedure or treatment. For example, in the 1920s the countryside surrounding the Sardinian villages of

Posada and Portotorres became the first sites in Europe where Paris Green was used to control mosquito larvae; while this arsenic powder demonstrated deadly efficacy against the malaria vector, it also showed plenty of dangerous side effects on animals and humans. Again several years later, inhabitants of Posada became the first Italians to be administered a drug called Plasmochine instead of quinine as a prophylactic against the malaria parasite. Not surprisingly, when George MacDonald, director of Britain's Ross Institute, contacted Missiroli in 1946 about testing out yet another antimalarial called Paludrine, Missiroli once more suggested that the experiment be conducted in Posada. "The trials should take place in Sardinia," Missiroli wrote back, "since fortunately malaria has practically disappeared from central Italy."[10]

Entranced by the euphoria of medical progress, many malaria investigators downplayed or ignored ethical considerations in their experiments. It is appalling but not altogether surprising that prisoners and mental patients were routinely inoculated with malaria parasites and were then administered experimental drugs or subjected to experimental procedures in order to test possible cures. Missiroli's laboratory worked closely with Rome's psychiatric clinics, where patients with advanced syphilis were institutionalized and then inoculated with malaria. By inducing high fevers, this malaria therapy, as it was called, helped to attenuate the psychotic effects of syphilis and provide some relief from that disease until these syphilitic patients were brought out of their malarial stupor two or three weeks later with the administration of quinine. Missiroli and his colleagues, along with several other American and European malariologists, considered malaria therapy an ideal method for testing the efficacy of novel antimalarial remedies and drugs. Although "Smalarina" and "M.3," for example, were just two substances that may have demonstrated certain advantages over other medications used at Rome's Asylum of Santa Maria della Pietá, most of Missiroli's trials undoubtedly showed that the patients undergoing malaria therapy would have been better off simply taking quinine.[11]

War accelerated medical testing by multiplying opportunities for experimentation and by lowering ethical standards. From the perspective of generals and colonels, the threat of epidemics spreading through the front lines demanded immediate action. Medical researchers scrambled for cures, sometimes abandoning their Hippocratic Oath. A case in point is the famous typhus threat at Naples in the winter of 1943–44, which saw the first widespread civilian use of DDT. Generally celebrated as an Allied triumph in which military doctors intervened at the eleventh hour to quell a major louse outbreak and so extinguish the incubating typhus epidemic, this episode of preventive medicine relied on massive civilian spraying of a barely tested pesticide. Each week, spray nozzles were pushed under the arms and into the crotches of hundreds of thousands of men and women, infants and elderly: "the sight of persons on the street with powdered hair and clothing was too common to cause comment." Some three million separate DDT dustings were performed on Neapolitans over a six-month period. The toxic aftermath could have been catastrophic.[12]

Nonetheless, Gen. Morrison Stayer and Col. William Stone, after consulting health experts such as the Rockefeller Foundation's Fred Soper, decided on the spot that the risk of epidemic typhus outweighed the potential dangers of systemic poisoning by DDT. And dangers there were. As historian Edmund Russell reveals, one researcher who had conducted trials with DDT a few months earlier at the U.S. government's Orlando laboratory noted that "The preliminary safety tests, made with full strength DDT, had been somewhat alarming. When eaten in relatively large amounts by guinea pigs, rabbits and other laboratory animals, it caused nervousness, convulsions or death, depending on the size of the dose."[13] Needless to say, it is doubtful that many of the Neapolitans who lined up for their biweekly delousing sessions were shown the results of the Orlando study.

A review of Italy's recent military history therefore makes it clear that war not only spread infectious diseases, it also promoted the search for cures, often under abbreviated safety protocols. Bomb craters and reversed drainage pumps aggravated the malaria threat while pesticide development and human experimentation favored its control. Or, as Paul Russell saw it, war conditions spread malaria through "troop mobility and dispersion, necessarily based on tactics and not on sanitary conditions; a great deal of nocturnal activity; difficult logistics, especially in combat zones; enemy action, mines, and booby traps; and combat tension when the chief concern is not malaria control but immediate life and death." He also believed that war conditions aided the control of malaria by providing "complete authority of the commanding officer, uniformity of living habits of the personnel, and ample anti-malaria funds and supplies." By broadening biological knowledge of mosquitoes and by accelerating the understanding of the plasmodium, Russell concluded, "there can be no doubt that antimalaria activities of World War II constituted a prime factor in the development of the present move for worldwide malaria eradication." In other words, the state of emergency that is war channeled scientific intelligence and energy, multiplying the benefits of human genius along with the penalties of human folly. The linked history of war and disease is a history of greater means producing greater ends, a history of greater human desperation countered by greater human hope.[14]

The Sardinian Project

By 1945, the Fascists and Nazis had surrendered, but typhus and malaria had not. Following the massive DDT campaign in Naples, the Rockefeller Foundation, with assistance from the Italian government and United Nations relief monies, planned an even bigger and more ambitious antiarthropod campaign on the island of Sardinia. This time the enemy was not the louse but the mosquito, and the resulting battle was even closer to a real military operation. From 1946 to 1951 a special corps—the Ente Regionale per la Lotta Anti-Anofelica di Sardegna, referred to by the acronym ERLAAS—was formed to exterminate

malaria-carrying mosquitoes throughout the island, using jeeps, airplanes, spray guns, tons of DDT, and thousands of uniformed men. As in Naples, this project also targeted the vector rather than the parasite, but it was aimed at eradication rather than control. As Fred Soper explained: "Mass dusting in Naples was not a louse eradication project, it was a typhus control measure for reducing the louse population to a point where typhus transmission would cease." The goal of ERLAAS was to exterminate every last malaria-carrying mosquito on an island the size of Vermont. As a *lotta*—or struggle—ERLASS's undertaking was a paramilitary operation. It made the Naples project look easy.[15]

Although Soper was the mastermind of the Sardinia Project, DDT was its chief weapon. Now armed with what Soper called "an almost perfect insecticide," the Rockefeller Foundation hoped to turn Sardinia into a demonstration site in the worldwide fight against malaria. If *Anopheles* could be eliminated locally, it might be eliminated globally. Although scattered mosquitoes were still buzzing in Sardinia at the end of the project, Sardinians and the Sardinian environment would never be the same again.[16]

There were in fact various precedents for the Sardinian Project. A few months before the dusting of DDT in Naples, Soper and members of the Pasteur Institute had supervised smaller louse-killing projects in Algiers, including those at various prisoner-of-war camps, Arab villages, and the Maison Carrée Prison. After observing the "striking results" obtained through these initiatives, the Allies invited the Rockefeller Foundation to establish a Malaria Control Demonstration Unit for testing the efficacy of DDT in killing mosquitoes at Castel Volturno, and a few months later, at the Tiber delta. By summer of 1945, Missiroli's laboratory was overseeing other fumigation projects in the battlefields of Cassino, where sprayers tried out various concentrations of DDT as well as coating the insides of houses and animal shelters. By war's end, Italian health officials were spraying DDT up and down both of the country's coasts and, in Sicily, using the wonder insecticide to kill flying mosquitoes, to kill mosquito larvae in water, and—as an added bonus—to kill bothersome houseflies. Only Sardinia was kept out of their jurisdiction; as Italy's most malarious place, Sardinia was reserved for the investigative trials of ERLAAS.[17]

Besides these DDT-spraying precedents, there were also vector-eradication precedents. In 1938–40 in Brazil, Soper had supervised the successful eradication of another malaria vector, *Anopheles gambiae,* by the strategic use of Paris Green. In 1942 in Egypt, he again directed the eradication of *gambiae* mosquitoes along the upper Nile using similar methods. Such projects really represented *local* eradication, as this species continued to thrive outside of spray areas. Soper's dream, though, was complete eradication, a term once reserved for disease but increasingly applied to insects. According to Soper, eradication was "the ultimate in species reduction and implies the world-wide extermination of a species." In the case of Sardinia, the elimination of a disease vector across an entire island was expected to demonstrate in microcosm the prospects of global eradication. During the same years as the ERLAAS initiative,

plans were also made for eradicating mosquitoes on the islands of Cyprus and Crete. But the Cypriot and Cretan campaigns would not be as thorough or as deadly as the Sardinian one.[18]

In 1948 the London-based Shell Petroleum Company sent a film crew to Sardinia to take footage of the mosquito-eradication project for a planned documentary recording this historic malaria experiment. Proposed by Rockefeller Foundation leaders and financed by Shell, the thirty-five-minute film, titled *The Sardinian Project,* captured the warlike tenor of this eradication effort. Between scenes of men marching across the countryside shouldering spray tanks, fumigating wells and streams, digging canals for draining swamps, even exploding dynamite to hasten excavation or using flamethrowers to clear brush, the film's narrator explained that ERLAAS was a true military operation. "In November 1947, the first phase of the all-out campaign opened," said the narrator. When the five-year project ended, over $11 million had been spent and thousands of men employed to mix and spray, dig and drain, fix, plan, check, supervise. The method was straightforward enough: locate all known water patches on the island; drain them or spray them with DDT (or Paris Green); spray DDT on the inside walls of every dwelling, human or animal; check all such places for surviving mosquito larvae or adults, and, if any were found, spray again. Official records indicate that more than a million separate water sources were located and sprayed. Cars, trucks, helicopters, airplanes, boats, maps, boots, and masks equipped an average seasonal crew of ten thousand workers—thirty-two thousand at its height—almost all Sardinians, except for project administrators, who were mostly Americans or other foreign experts employed by the Rockefeller Foundation. *The Sardinian Project* was followed by *Battaglie di Pace* (Battles of Peace), an Italian short that would be projected in cinemas across the island. Then, in 1950, *Adventure in Sardinia* was released, which was a lighter, more entertaining version of Shell's first film. Its narrator proclaimed that "ERLAAS was indeed an army."[19]

War metaphors permeated more than these documentary films. Throughout ERLAAS publications, spray-gun-toting soldiers were shown shooting at winged enemies. In a monthly report, *il Pericolo Sovrastante* (the Overwhelming Danger) was gunned down into the sea to become *il Nemico Fulminato* (the Annihilated Enemy). Such images bear out Edmund Russell's observation that creepy crawlers were often represented as humanoid enemies, particularly when real wars were close at hand and when one could kill by the press of a button. As in the United States, DDT in Sardinia became the insecticide bomb in the water well, the mushroom cloud under the sink. As Russell shows, analogies between insects and humans, between insecticide gas and nerve gas, were simply too close to be ignored by those searching for remedies to the day's immediate crises. Experts in pest control were sometimes recruited for human weapons research. A war-obsessed world saw its other struggles in warlike terms. Little surprise, then, that for ERLAAS administrators, enemies could be Nazi-Fascist as well as Plasmodium-arthropod (figure 6.3).[20]

6.3 Two-panel cartoon from a pamphlet distributed in Sardinia by ERLASS (Ente Regionale per la Lotta Anti-Anofelica di Sardegna). The first panel dubs the mosquito a "pericolo sovrastante," or overwhelming danger, and the second panel depicts it as the "nemico fulminato," or the enemy annihilated.

But just as all analogies risk overextension, it became increasingly apparent that mosquitoes did not pilot warplanes, nor did malaria wear a swastika. ERLAAS was ultimately an entomological experiment: an investigation for testing the feasibility of *Anopheles* eradication. ERLAAS was not an act of war, nor was it a public-health measure for controlling malaria. At the beginning of the project, eradicating the mosquito and controlling the disease seemed to require roughly the same approach: a generous spraying of DDT. Yet as the project wore on, ERLAAS supporters came to realize that these two goals could require dramatically different procedures, especially as mosquitoes kept buzzing while malaria cases kept dropping. Marston Bates, a Rockefeller Foundation ecologist who kept careful watch on the Sardinian Project, later suggested that ERLAAS participants "were sometimes uncertain as to whether they were conducting an experiment or implementing a public-health measure." Sardinian Project supporters pointed out that investing in Sardinia's long-term health also injected much-needed cash into this island's desperately poor economy. But there were surely cheaper ways to control malaria, and there were clearly better ways to spend the money: on hospitals and schools, or on railroads and harbors, for example. While the coming of ERLAAS meant that shepherds-turned-DDT-sprayers could finally "carry coins in their pockets," as one sprayer put it, it is also true that such workers might well have funneled their efforts into more crucial work.[21]

In fact, those in the know understood that malaria could be extinguished with only moderate DDT spraying. In 1944 trials at the Tiber delta, both Missiroli and Soper had observed spectacular malaria retreats with even cursory DDT coverage. Missiroli predicted that malaria could be wiped out across all of Italy in just two to three years, and in fact Italy's health ministry would do just that upon adopting Missiroli's recommendations—except in off-limits Sardinia. Even though Sardinia's rates of malaria incidence and malaria mortality declined just as rapidly as those on the mainland, ERLAAS sprayers pushed on for several more years, refilling and spraying anew—searching out every last *Anopheles labranchiae* even as mosquito DDT resistance set in. In only the second year of the Sardinian Project, ERLAAS director John Logan made the job of malaria control sound trifling as compared to vector eradication. When he answered queries from French health authorities who were confronting the rising malaria problem on the nearby island of Corsica, he calculated that just one-third to one-fourth as much DDT would be needed if their goal was *merely* to control malaria instead of to eradicate mosquitoes.[22]

True, there was the possibility that the strategy of control would require continual respraying over the years to keep malaria in check, so that vector eradication would represent the best long-term solution to malaria. But experience across the rest of Italy, in Greece, and in the South Pacific was already suggesting that light DDT spraying was sufficient to break the malaria cycle. An 80 percent reduction in the vector population was enough to quell a malaria epidemic. In fact in the American experience with malaria, as Margaret Hum-

phreys argues, zealous DDT spraying in the southern states during the 1940s was akin to "kicking a dying dog," so imminent was the demise of malaria in the United States through other control methods. It seems that Sardinia's dying dog was also being kicked—and hard. Immediately before the war and before the advent of DDT, levels of malaria in Sardinia had dropped to an all-time low; and even with temporary wartime relapses, malaria was assuredly on the way out on this island, with or without Paul Müller's insecticide discovery.[23]

Sardinians then and Sardinians now hardly realize that ERLAAS sprayers were little more than underpaid lab assistants. "Today, thanks to DDT," announced a recent commemorative exhibition at the elementary school of Birori, Sardinia, "malaria has disappeared from Sardinia and from other temperate regions." Ex-ERLAAS-sprayer Giuseppe Foeddu, when interviewed fifty years after the Sardinian Project, expressed gratitude to the Americans: "thanks to them, malaria had been snuffed out." Elderly Giuseppe Flore, another ex-sprayer in the project, offered a perspective shaped by fifty years of hindsight when he remarked that "the word DDT is synonymous with savior from disease, with well-being, and for me a steady job with an income. . . . Luckily they invented it, otherwise the feared and terrible malaria would still have been with us, causing many deaths, especially of children and other defenseless and vulnerable individuals." But Fascist-era quinine programs and marsh-drainage schemes, together with new mosquito-proof housing were already driving malaria away when the men with spray tanks appeared on the horizon. Most Sardinians continue to argue that a little DDT in their grandparent's (and their own) blood is better than suffering from malaria. Or as elderly Mariantonia Loddo from Ortueri expressed her views: "Yes, I remember the anti-malaria campaign. They entered people's houses telling us that it wasn't poisonous. And now see what they say! Well . . . they did it anyway because in those days it was a true and real epidemic." She and most others who witnessed the project rarely suggest that DDT might have been avoided altogether, or even that the spraying might have been limited to as little as one-quarter of the amount of insecticide actually applied.[24]

Indeed, health experts were in wide disagreement about how malaria should be eliminated in Sardinia. The first director of ERLAAS, John Kerr, resigned just a few months after the start of the project, declaring that island-wide mosquito eradication was an unrealistic goal. As Kerr exclaimed to Fred Soper, "In my opinion, the organization of comprehensive anti-larva work in the portion of Sardinia which has an elevation of up to 1,000 meters is an impossible task. Call me a pessimist if you will, but the word *impossible* is in my vocabulary, and I intend to keep it there."[25]

Although plenty of other malariologists, including Italy's Missiroli, believed that the Sardinia Project could and should be carried out to completion, other Italians lobbied for vector control over vector eradication. Several of Sardinia's own experts, including two of the island's four Medici Provinciali, called for a return to "Italian methods" in lieu of the new "American methods."

Italy's traditional programs of swamp draining and oiling, along with widespread quinine distribution, became more appealing as reports accumulated about DDT-poisoned bees, fish, livestock, and even people. ERLAAS opened a public-relations office and found itself a defendant in numerous lawsuits claiming property damages. That the courts rapidly and easily dismissed most such claims indicates that ERLAAS was not reluctant to exert its influence with friends in high places.[26]

Historian Eugenia Tognotti argues that the Sardinian Project was part and parcel of the political schism dividing the island during the postwar years. The Christian Democrats were vying with the Communists as the majority party in this war-torn land, with ERLAAS sometimes being portrayed in newspapers as pro-American and anti-Communist. Tognotti's most compelling evidence is a letter from Britain's Lord Boyd Orr, director of the United Nations' Food and Agriculture Organization (FAO) and a 1949 Nobel Prize winner, addressed to America's ambassador to Britain about the desirability of maintaining the Rockefeller Foundation's presence in Sardinia after the end of the mosquito project. Orr recommended that the Rockefeller Foundation stay on to develop an islandwide economic plan in order to quell the rising pro-Communist sentiment there. But while there is little question that ERLAAS found itself in the midst of party and regional struggles (in which Sardinia emerged as a semiautonomous region), there is scant evidence to suggest that ERLAAS was designed by the United States as a strategic move in an escalating Cold War. America's military presence continued to grow in Sardinia, but this presence arose as a response to subsequent events unfolding in the rest of Europe rather than as a premeditated political maneuver thinly disguised as a malaria project. While Sardinia did serve as an Allied airbase for bombing northern Italy, it is unlikely that ERLAAS was, as some critics claim, really a front for establishing a kind of gigantic, permanent aircraft carrier for safeguarding American interests in the Mediterranean.[27]

Other interpreters of the Sardinian Project suggest that it should be considered primarily an entomological experiment, or a public-health project, or perhaps even a pork-barrel relief effort, rather than a tentacle of American foreign policy. Championed by an elite corps of technocrats acting with somewhat too much hubris and hegemony, the Sardinian Project was all of these things. There are many ways to explain the Rockefeller Foundation in Sardinia, most of which depend on the fortuitous encounter of pests and disease with politics and technology. As Marston Bates notes in his preface to the project's final report, "Each reader will probably draw his own moral from the tale; but that is the beauty of it. The facts are here, for the thoughtful reader to ponder in terms of his own interests, prejudices and developing plans."[28]

Yet together with these other interpretations, the Sardinian Project must also be viewed as an intersection of war and environment. Armed combat and the natural world must be considered in tandem when explaining the origins and effects of Sardinia's DDT dousing. The Allied troops who stormed Italy's

malaria-infested beaches set the stage. A rich Italian tradition of experimental malariology, coupled with the discovery of a new pesticide, the Rockefeller Foundation's desire to spray it, and the United Nations' willingness to pay for it all produced the largest mosquito battle in history. Sardinia's ecosystems, its economy, its inhabitants' blood chemistry were forever altered. Malaria disappeared on the island, with warfare first worsening the epidemic and later providing the resources that led to its demise. After five years and 5.7 million liters of DDT solution, not just mosquitoes, but bees, fish, birds, and livestock were all poisoned. Meanwhile, Sardinia's massive DDT spraying also allowed some of the island's wetlands to remain wet, as humans no longer drained them in order to combat malaria. Copious DDT likewise meant that Sardinians were spared the nauseous side effects of quinine. War and its aftermath modified the land and its inhabitants, for bad as well as good.[29]

Today the Second World War is still etched across Sardinia's landscape. New buildings in Cagliari have been constructed on the rubble of houses destroyed during air raids. There are the old and the new military airbases where NATO's supersonic aircraft refuel and plan missions. There is the hundred-square-mile military proving ground in the southwest peninsula of Teulada where NATO war games leave tank tracks and bomb craters in the rolling grassland alongside beaches gouged by landing crafts. But while mosquitoes now breed copiously in the puddles formed by these military maneuvers, such mosquitoes no longer carry the malaria plasmodium. The Sardinia Project's three-to-four-order overkill of malaria has left a rebounding population of *Anopheles* with an appetite for blood meals but scant chance that they will again threaten the islanders with the disease. Bomb craters as well as plasmodium-free mosquitoes are part of Sardinia's World War II legacy.

DDT Legacies

The simple story of war and malaria in modern Italy centers on how military emergencies accelerated the development of DDT, which led to quick eradication of the disease. Fuller studies of this case of war and malaria will explore how grain harvests plummeted when the enemy flooded fields for incubating new malaria epidemics, how novel pesticides modified ecosystems as well as human health, how military doctors could begin paying more attention to shrapnel wounds than to malarial fevers, and how insect battlefields helped to pave the way for NATO's modern infrastructure. War and malaria—these subsets of culture and nature—must be understood for what each did to the other, and for what the resulting changes would mean for each. At one point in his classic history of Italy, Dennis Mack Smith declares that malaria eradication may be "the most important single fact in the whole of modern Italian history." Yet one must also consider that Italy's victory over malaria was intimately linked to warfare, and that the methods of battling malaria were distinctly warlike.[30]

Marston Bates, the well-known ecologist and observer of the Sardinian Project, went on to consider larger questions about humanity's place in the natural world. Together with Carl Sauer and Lewis Mumford, Bates would help to organize the famous 1955 Marsh Festival that convened seventy of the day's leading environmental scholars to discuss "Man's Role in Changing the Face of the Earth." In his own commentary on this meeting, Bates called special attention to the role played by war in producing earthly changes. "Certainly, war has been a tremendously important agency in this process," he declared. Yet the subject of war, he pointed out, had attracted almost no discussion at the meeting. "Even though we have talked about war so little, clearly it has been hanging over our minds all through our discussions, as it hangs over the minds of all men in the Western world these days." Although Bates offered few illustrations of war's dramatic environmental effects, he implored his colleagues to begin tracing and explaining such effects. Surely Bates's own reflections on Europe's war-torn condition and on military spin-offs such as the Sardinia Project convinced him of how drastically warring humans might transform the ecosystems on which they depend.

Indeed, Bates's comments seem especially pertinent in regard to his own specialty of entomology. For example, one insect survey in Sardinia reveals that only sixteen out of twenty-four black fly species (or *Simulli*) survived the island's massive DDT episode. Although but a single example in one small corner of the world, this insect survey reflects the degree to which war's chemicals and war's relief programs can alter the fabric of nature.[31]

But war does not always destroy nature or ruin the land. It is true that war-developed pesticides seriously threatened Sardinia's fish-farm industry during the summers of 1947 and 1948, when mullet being raised in coastal marshes died by the thousands after airplanes blanketed these areas with DDT. Elsewhere in Sardinia, however, antimalaria squads transplanted gambusia fish into various streams and ponds in the hope that these North American imports would slurp up mosquito larvae and thus limit mosquito populations. Mullet stocks plummeted while gambusia numbers soared. While DDT spraying assuredly killed innumerable arthropods that relied on Sardinian marshes, the advent of powerful pesticides meant that engineers no longer drained marshes for health reasons. Innumerable aquatic creatures in these marshes owed their lives to DDT. It is more accurate to say that Sardinia's postwar malaria project remade rather than ruined the local ecosystems.[32]

The relationships between war and malaria, between humans battling humans and humans battling pathogens, are complicated, however. Today 23 percent of Sardinians are susceptible to favism, a hereditary enzyme deficiency involving red blood cells that, while making it difficult (or fatal) to digest legumes such as fava beans, also provides some protection against malaria. Evolutionary pressures over the centuries meant that highly malarial areas gave a selective advantage to people with favism. Now that Sardinians no longer confront malaria, there are no advantages for them to be born with favism; so

this genetic condition is disappearing from the local gene pool. Sardinia's war on mosquitoes modified local ecosystems as well as human genes. Wars produce pesticides; pesticides control pathogens; pathogens reorder human DNA. Rockefeller Foundation experts reached into Sardinia to pull out the malaria threat and, like John Muir, found it hitched to everything else in the universe.

War comes in many forms, involving guns or words, physical injuries or psychological threats. War is armed and intense struggle, accelerating the interaction of the human and nonhuman, intentionally and unintentionally. War spreads disease and fashions remedies for its cure. In the case of Italy, people were beneficiaries as well as victims of such remedies. The tentacles of war turned Sardinia's flora and fauna, its mountains and coasts, into an ecological laboratory as well as a political proving ground, changing the face of the earth as well as the structure of the human genome.

Notes

1. See John R. Meyer, "Pests of Medical Importance," http://www.cals.ncsu.edu/course/ent425/text18/medical.html, accessed November 10, 2007; Fiammetta Rocco, *Quinine: Malaria and the Quest for a Cure That Changed the World* (New York: HarperCollins, 2003), 178–79; Paul Russell, Introduction to *Communicable Diseases—Malaria,* vol. 6, *Preventive Medicine in World War II,* comp. Office of the Surgeon General, Department of the Army, 9 vols. (Washington, DC: Government Printing Office, 1955–), 2, 9, 262.

2. See Alberto Coluzzi, "L'eradicazione della malaria. Una sfida al mondo," *Annali della Sanità Pubblica* 22, no. 2 (1961): 241–53.

3. Raymond Fosdick, *The Rockefeller Foundation: A Review for 1946* (New York: n.d.), 19; Missiroli's graph is reproduced in many of his publications, including Alberto Missiroli, "La Malaria nel 1944 e misure profilattiche previste per il 1945," *Rendiconti dell'Istituto Superiore di Sanità* (1944): 639.

4. Gilberto Corbellini and Lorenza Merzagora, *La Malaria: Tra Passato e Presente* (Rome: Museo di Storia della Medicina [Museum of the History of Medicine], 1998), 63.

5. Margaret Humphreys, *Malaria: Poverty, Race, and Public Health in the United States* (Baltimore: Johns Hopkins University Press, 2001), 147; William M. Tsutsui, "Landscapes in the Dark Valley: Toward an Environmental History of Wartime Japan," in *Natural Enemy, Natural Ally: Toward an Environmental History of War,* ed. Richard P. Tucker and Edmund Russell (Corvallis: Oregon State University Press, 2004), 209.

6. Paul Russell, Introduction, 5; Alberto Missiroli to the Direttore Generale dell'Istituto Superiore di Sanità [hereafter ISS], November 3, 1943, busta 6, fasc. 19, Laboratorio di Parassitologia, ISTISAN, Archivio Centrale dello Stato, Rome. See also Frank Snowden, *The Conquest of Malaria in Italy, 1900–1962* (New Haven, CT: Yale University Press, 2006).

7. Alberto Missiroli to the Direttore Generale dell'ISS, November 29, 1943, and Alberto Missiroli to the Sottosegretario di Stato, August 24, 1944, both in busta 6, fasc. 19, Laboratorio di Parassitologia, ISTISAN, Archivio Centrale dello Stato, Rome; Paul Russell, Introduction, 6.

8. Alberto Missiroli to the Gabinetto del Ministro Ministero dell'Interno, Rome, August 20, 1943; Alberto Missiroli to the Direttore dell'Ufficio d'Igiene del Governatorato di Roma,

November 2, 1943; Alberto Missiroli to the Direttore Generale dell'ISS, November 29, 1943; Alberto Missiroli to the Sottosegretario di Stato, August 24, 1944; "La Malaria nella Zona di Maccarese," January 24, 1947, all in busta 6, fasc. 19, Laboratorio di Parassitologia, ISTISAN, Archivio Centrale dello Stato, Rome; personal communication with Mario Coluzzi, son of Alberto Coluzzi, May 15, 2005.

9. Letter from Alberto Missiroli to the Sottosegretario di Stato, August 24, 1944; "La Malaria nella Zona di Maccarese," January 24, 1947.

10. L. W. Hackett, *Malaria in Europe: An Ecological Study* (London: Oxford University Press, 1937), 17; letter from George MacDonald to Missiroli, May 4, 1946, busta 6, fasc. 19, Laboratorio di Parassitologia, ISTISAN, Archivio Centrale dello Stato, Rome.

11. Letter from Missiroli, August 11, 1938, busta 6, fasc. 19, Laboratorio di Parassitologia, ISTISAN, Archivio Centrale dello Stato, Rome. See also Marion Hulverscheidt, "German Malariology Experiments with Humans, Supported by the DFG until 1945" (2003), http://www.geschichte.uni-freiburg.de/DFG-Geschichte/MedTagungAbstracts.htm, accessed June 15, 2005.

12. F. L. Soper, W. A. Davis, F. S. Markham, and L. A. Riehl, "Typhus Fever in Italy, 1943–1945, and Its Control with Louse Powder," *American Journal of Hygiene* 45, no. 3 (1947): 305–34, esp. 317, 320.

13. Edmund P. Russell, "The Strange Career of DDT: Experts, Federal Capacity, and Environmentalism in World War II," *Technology and Culture* 40, no. 4 (1999): 770–96, esp. 780; Paul Russell, Introduction, 9.

14. Paul Russell, Introduction, 5, 9.

15. Soper et al., "Typhus Fever in Italy, 1943–1945," 325.

16. Ibid.

17. Fred L. Soper, "Introduction of DDT to Italy, 1943–1945," *Rivista di Parassitologia* 20, no. 4 (1959): 403–9; Fred Soper to L. W. Hackett, January 20, 1959, Fred L. Soper Papers, U.S. National Library of Medicine; Blanche Armfield, *Organization and Administration in World War II* (Washington, DC: Office of the Surgeon General, Department of the Army, 1963), 292.

18. J. R. Busvine, "Eradicating the Mosquito," *Discovery* (March 1950): 85–89; Fred L. Soper, "Species Sanitation as Applied to the Eradication of (A) an Invading or (B) an Indigenous Species," in *The Proceedings of the Fourth International Congresses on Tropical Medicine and Malaria* (Washington, DC: Government Printing Office, 1948), 48; Col. D. E. Wright, "The Program of Insect Control on Crete" [1946], in United Nations Relief and Rehabilitation Administration records, Office of the Historian, Mongraphs Greece 22, Malaria & Sanitation, 1946 (S-1021–0034, 1945–1946, PAG 4/4.2.:34), United Nations Archives, New York City.

19. "Final Commentary: The Sardinina Project," Shell filmscript, received December 21, 1949 (Rockefeller Archive Center [hereafter RAC]), 1.2, 751, 16, 138), 3; John A. Logan, *The Sardinian Project: An Experiment in the Eradication of an Indigenous Malarious Vector* (Baltimore: Johns Hopkins University Press, 1953), 116; John Logan, diary entry for September 27, 1947 (RAC); "ERLAAS Monthly Report," April, 1949, 16 (RAC, 11.2, 700, 16, 135); "The Sardinian Project" (1948; 35 minutes), Shell Petroleum Company, Ltd.; "Battaglie di Pace," Penco Film (n.d.); "Adventure in Sardinia" (1950; 20 minutes), British Pathé in Association with the Nucleus Film Unit (RAC).

20. Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring* (New York: Cambridge University Press, 2001), 53–73.

21. Marston Bates, Preface, in Logan, *The Sardinian Project* (1953), x; quotation of ERLASS sprayer taken from the Malaria Oral History Project, directed by Pier Luigi Cocco, Istituto di Medicina del Lavoro, University of Cagliari.

22. G. A. Canaperia and T. Patrissi, "La malaria in Italia nel periodo bellico e post-bellico," *Rivista di Malariologia* 27 (February 1948): 1–28; letter from John Logan to Leach, June 16, 1947 (RAC, 1.1, 502, 1, 2).

23. Margaret Humphreys, "Kicking a Dying Dog: DDT and the Demise of Malaria in the American South, 1942–1950," *Isis* 87 (1996): 1–17.

24. Birori School, Sardinia, at http://www.macomer.net/scuolabirori/presentazione.html, accessed November 5, 2003. Interview quotations taken from Malaria Oral History Project, directed by Pier Luigi Cocco; Marcus Hall, "Today Sardinia, Tomorrow the World: Killing Mosquitoes," *BardPolitik: The Bard Journal of Global Affairs* 5 (Fall 2004), available online at www.bard.edu/bgia/journal/v015, accessed June 15, 2005.

25. Letter from John Kerr to Fred Soper, June 6, 1946 (RAC, 1.2, 700, 12, 104).

26. John Logan, diary entry for November 19, 1948 (RAC).

27. Eugenia Tognotti, *Americani, Comunisti e Zanzare: Il piano di eradicazione della malaria in Sardegna tra scienza e politica negli anni della guerra fredda (1946–1950)* (Sassari: Collana Documenti e Opinioni, Editrice Democratica Sarda, 1995), 26, 47–48.

28. Marston Bates, in Logan, *The Sardinian Project,* xi.

29. Logan, *The Sardinian Project,* 389.

30. Dennis Mack Smith, *Italy: A Modern History* (Ann Arbor: University of Michigan Press, 1959), 494.

31. Marston Bates, "Retrospect," in *Man's Role in Changing the Face of the Earth,* ed. William L. Thomas et al. (Chicago: University of Chicago Press, 1956), 1140; Sardinia insect survey furnished by Dr. Carlo Contini, Cagliari, Italy.

32. Information about DDT poisoning of Sardinia's mullet stocks was furnished by Dr. Carlo Contini in a personal communication, April 2004.