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Pyrethrum and the Second World War: Recontextualising DDT in the Narrative of Wartime Insect Control

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Abstract: Historians have long recognised that DDT's fame began with extraordinary propaganda late in the Second World War, yet heroic narratives that centre the chemical still shape historical understanding. Two false assumptions inform much of the existing scholarship on wartime insect control: one is that without DDT the Allies had no protection from malaria and typhus; the other is that DDT was significantly more toxic than any alternative insecticide available. This paper tells a very different story of wartime insecticides. We recontextualise DDT in the wider wartime technological landscape and in so doing show the enduring significance of the natural insecticide, pyrethrum. DDT was never solely responsible for protecting troops and civilians from malaria and typhus and its deployment did not render all existing insecticides obsolete. Claims about the significance of DDT often work by writing out the existence of alternative methods of controlling vectors or by downplaying the efficacy of existing materials and practices.

Keywords: pyrethrum; DDT; World War II; malaria; typhus

Introduction

In April 1943, a high-ranking British officer stationed in Washington declared that the military's most widely used insecticide needed to be designated a "munition of war."[1] This insecticide, pyrethrum, was so effective against insect pests, and so versatile, that it had become the subject of considerable Anglo-American wrangling over the correct allocation of supplies. The significance of pyrethrum for wartime insect control has been neglected by historians, however, in favour of focussing on the importance of the novel material Dichlorodiphenyltrichloroethane (commonly known as DDT).

The case of DDT is a good example of a more general tendency in the history of science, technology and medicine to organise narratives around heroic stories that were constructed in the past.[2] The idea that DDT was a "miracle weapon" in the fight against insect pests was first promoted in American press coverage of a typhus control campaign in Naples during the winter of 1943-44.[3] The heroic tale that subsequently emerged was one in which DDT was responsible for saving the lives of countless soldiers and civilians from typhus and malaria during World War II (WWII); as if no other means of controlling these diseases existed.[4] While historians have recognised that the fame of DDT was the result of extraordinary propaganda towards the end of WWII, claims about the unique significance of DDT in the war have given shape to our historical understanding. One, sometimes two, false assumptions have come to inform much of the scholarship: one is that without DDT the Allies would have been left unprotected from malaria and typhus, the other is that DDT was considerably more toxic than any alternative insecticide available at the time.[5]

[1] Lt-General Gordon Macready of the British Joint Staff Mission to Lt-General Brehon B. Somervell, letter, 19 April 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[2] Other work that has shown the problem of basing historical narratives on myths that were constructed around the time of the Second World War include, Hermione Giffard, "Engines of Desperation: Jet Engines, Production and New Weapons in the Third Reich," *Journal of Contemporary History* 48, no. 4 (2013): 821-44; for an interesting argument that shows the significance of sulphonamides rather than penicillin in WWII see Diana Davenport, "The War Against Bacteria: How were Sulphonamide Drugs Used by Britain During World War II?" *Medical Humanities* 2, no. 38 (2012): 55-8.

[3] Thomas R. Dunlap, *DDT: Scientists Citizens and Public Policy* (Princeton: Princeton University Press, 1981), 1-3, 61-62; David Kinkela, *DDT and the American Century: Global Health, Environmental Politics and the Pesticide that Changed the World* (Chapel Hill: The University of North Carolina Press, 2011), chap. 2; Edmund Russell, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring* (Cambridge: Cambridge University Press, 2001), 127-30.

[4] Dunlap makes the surprising claim that DDT protected, "millions of soldiers and civilians against insect-borne diseases" during WWII, Dunlap, *DDT*, 3.

[5] Dunlap, *DDT,* 3, 60, 62; John H. Perkins, *Insects, Experts and the Insecticide Crisis: the Quest for New Pest Management Strategies* (New York: Plenum Press, 1982), 10; John H. Perkins, "Reshaping Technology in Wartime: the Effect of Military Goals on Entomological Research and Insect-Control Practices," *Technology and Culture* 19, no. 2 (1978): 169-86; Kinkela states that DDT, "single-handedly

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This paper tells a very different story of wartime insecticides. Instead of reading back into the history of the war from the point at which DDT was being celebrated as a miracle, we recontextualise the chemical in the wider technological landscape that existed at the time. This has two aspects; one is the recognition of the variety of insecticidal materials that were important during WWII, the other is a consideration of the relative place of insecticides as part of the array of practices that protected troops from diseases such as malaria. One result of our analysis is to show the enduring significance of pyrethrum throughout the war. DDT was never solely responsible for protecting troops and civilians from malaria and typhus and its discovery did not render all existing insecticides obsolete. The claims that have been made about the power of DDT, that it was the "atomic bomb" of insect control, for example, work by writing off alternative methods of vector control or by ignoring the considerable efficacy of some existing materials.[6]

The issue that is at stake here is the way stories of technological change are told. The consequence of repeating sensational claims about DDT in many of the existing accounts of wartime insecticides is to promote a picture of technological development in which the emergence of the new insecticide immediately rendered older alternatives obsolete; a sequential story of technological "evolution," where the superior technology has displaced one that was never completely adequate. The fact that technological change does not, in fact, often happen in this way is well established in scholarship. Historians have shown that older technologies often persist after the launch of newer ones; see Svante Lindqvist on the impact of electricity on gas usage for example, or the scholarship that shows the importance of horsepower for the German Army during the Second World War.[7] Here we show that the more accurate description of wartime insecticide use is that it was diverse, changing and responsive, and that the new co-existed with the old.

The standard narrative is overwhelmingly focussed on the wartime experience of the USA. It tells that America found itself without adequate disease protection for its troops after supplies

reversed the typhus epidemic in Naples," when pyrethrum was also used in this campaign, Kinkela, *DDT and the American Century*, 37. The most recent history is notable for showing that enthusiasm for DDT was not universal, even at the start, but then provides an account of wartime deployment of DDT that overstates its significance by writing out the use of other materials and practices in the fight against disease, Elena Conis, *How to Sell a Poison: the Rise, Fall and Toxic Return of DDT* (New York: Bold Type Books, 2022), 22-3, 26-7.

6 On the point that historians of technology have a tendency to focus on novelty and ignore older alternatives that are in widespread use, see David Edgerton, *The Shock of the Old: Technology and Global History Since 1900* (London: Profile Books, 2006).

7 Svante Lindqvist, "Changes in the Technological Landscape: The Temporal Dimension in the Growth and Decline of Large Technological Systems," in *Economics of Technology*, ed. Ove Granstrand, 271-88 (Amsterdam: North Holland, 1994); the literature on horses is described in Edgerton, *The Shock of the Old,* 35.

of pyrethrum from Japan were cut off in 1941.[8] In some accounts we find the claim that before DDT was taken up on a large scale in 1944 *no* material could effectively counter the threat posed to troops by mosquitoes.[9] Elsewhere, there is acknowledgement that pyrethrum was still in use amongst the American forces beyond the end of 1941, but this is accompanied by a focus on its main limitation. Perkins says that American louse powder (which contained pyrethrum) "was effective for only one week, too short a time when men are under the pressure of war."[10] The point is actually, of course, to establish the necessity of DDT.

In this paper we show just how effective and important the alternatives to DDT were. Our focus is on the many dimensions of the insecticide problem as seen from the British perspective, paying particular attention to the logistical and diplomatic work done to secure a continued supply of pyrethrum.[11] Pyrethrum was a potent, broad-spectrum insecticide with a variety of farming, household, and military applications. Our analysis reveals that Britain became convinced, by the spring of 1943, that the shortage of pyrethrum for its military resulted less from an absolute shortfall in production than from the fact that demand from farmers in the US was absorbing the available production. We explore the considerable effort that went into ensuring the continued availability and appropriate allocation of pyrethrum throughout the war.

Alongside efforts to ensure the effective deployment of existing insecticides, Britain and the US were engaged in the investigation of alternative chemicals. This search, which eventually focussed on DDT, is usually presented as the desperate attempt to find an insecticide to replace Japanese pyrethrum. In fact, scientists sought materials, such as synergists, that could extend pyrethrum supplies, so that this crucial material could be made to go further.[12] Actors at the time did not discuss pyrethrum as a material with limitations, but as an insecticide beyond comparison. DDT was first constructed as a *substitute* for pyrethrum (and rotenone and Paris Green) in the sense that its qualities were assessed in terms of whether it could do some of the work of these insecticides. The initial goal was not the replacement of pyrethrum with DDT but to conserve supplies of pyrethrum as much as possible.

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[8] Kinkela, *DDT,* 16-7. Perkins, *Insects, Experts and the Insecticide Crisis*, 124; Dunlap, *DDT*, 60.

[9] "No known insecticide would provide effective protection for forces on South Pacific islands," Dunlap, *DDT*, 60. This is untrue as pyrethrum was used by US forces in an effective aerosol bomb.

[10] Perkins, "Reshaping Technology," 175.

[11] There is also a need for other stories to be told, such as those from the Australian and Indian perspectives. See Kinkela for a particularly US-focussed account, claiming inaccurately that, "only the United States established institutional mechanisms to determine how and whether to use DDT extensively during the war," Kinkela*, DDT and the American Century*, 7.

[12] For the story of research into substitute insecticides on the American side, see Perkins, "Reshaping technology," 177. For the toxicological testing see, Frederick Rowe Davis, *Banned: A History of Pesticides and the Science of Technology* (New Haven and London: Yale University Press, 2014).

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By engaging with the considerable work that was done to maintain and conserve supplies of pyrethrum, and the qualities that made it so valued, we can more adequately grasp the advantage offered by DDT at the end of WWII. Again, the issue at stake here is the way stories of technological change are told; in this case why choices were made between one technology and another. Many of the things that have been said about DDT by historians in an attempt to convey its wartime significance—that it possessed high toxicity against insects, that it was effective against a wide range of vectors, that it posed little danger to animals—were also said about pyrethrum during the war. Recontextualising DDT by placing it in the context of a larger array of chemicals and practices, allows us to disentangle exactly what made this substance different to any alternative—its extraordinary persistence.

Decentring DDT also has broader implications for our understanding of the history of the Second World War. When supplies of pyrethrum from Japan were no longer available, the US and the UK looked to the British colony of Kenya for the chrysanthemum flowers that were the source of the insecticide. That the Allies were able to secure an alternative source of a key material so readily, rather than finding themselves in the midst of the insecticide crisis that the existing DDT narrative claims, speaks of nations whose ability to wage war successfully was underpinned by their capacity to mobilise supply networks; in this case, one that originated in the British colonial empire.[13] If the DDT story has been used to illustrate the notion that wartime victory resulted from technological superiority of the Allies, then the pyrethrum story shows instead the significance of the economic power of combatant nations that could readily identify and import new sources of the raw materials they needed.[14]

The Pyrethrum Problem

Britain's armed forces took insect-borne disease seriously from the outset of the Second World War and the use of insecticides formed one element in the prevention of typhus, a disease with a very high mortality rate, spread by body lice, and malaria, a mosquito-borne disease that could severely reduce combat effectiveness.[15] Pyrethrum was the principal insecticide chosen for mosquito control in the British forces and the most usual method of dispersal was via a kerosene spray. The solution was applied to the interiors of houses or tents in mosquito-affected

[13] David Edgerton, *Britain's War Machine*: *Weapons, Resources and Experts in the Second World War* (London: Penguin, 2012); David Edgerton, "Controlling Resources: Coal, Iron Ore and Oil in the Second World War," in *The Cambridge History of the Second World War*, ed. Michael Geyer and Adam Tooze, 122-48 (Cambridge: Cambridge University Press, 2015).

[14] Edgerton, *Britain's War Machine*.

[15] Mark Harrison, "Medicine and the Culture of Command: The Case of Malaria Control in the British Army During the Two Wars," *Medical History* 40, no. 4 (1996): 437-52. For mortality rates of typhus and malaria in World War II see Mark Harrison, *Medicine and Victory: British Military Medicine in the Second World War* (Oxford: Oxford University Press, 2004), 94, 134, 138.

areas. British forces were also issued with a louse powder to be applied to the seams of clothing. This powder, AL63, originally contained another natural insecticide, rotenone, a compound derived primarily from derris that was widely used in Britain to control pests of fruit and vegetables. Britain imported derris from the colonial territory of Malaya before supplies were cut off at the end of 1941. The US Army used pyrethrum in both its MYL louse powder and its anti-mosquito aerosol "bomb."[16]

Pyrethrum is a natural insecticide derived from the flowers of chrysanthemum. It was first cultivated in Persia and Croatia before introduction to Japan in the 1880s where it was grown on a large scale. Pyrethrum was an established material for the control of agricultural pests, flies, cockroaches and bed bugs in the USA and Britain before the Second World War, and its widespread use had been facilitated by the development of improved methods of application. A pyrethrum spray was developed by a German chemist, Gustav Giemsa, in 1910, and found to be very effective against mosquitoes.[17] Within a decade such sprays were on sale in the USA and Britain as household products for insect control; one well-known product was "Flit."[18] By the 1930s, large-scale malaria control campaigns had been fought using pyrethrum spraying, some with considerable success. The Rockefeller Foundation carried out extensive spraying experiments in India from 1938 and a major mosquito eradication campaign in Brazil was implemented between 1939 and 1940 using pyrethrum sprays, and Paris Green as a larvicide.[19] Clearly, large-scale programmes of vector eradication did not begin with, or rely upon, DDT. Pyrethrum was an effective, broad-spectrum insecticide that was convenient to use, presented no risk to humans and animals, and had a useful rapid "knock-down" effect on insects which meant that users could see the insecticide at work.

Prior to the war, Japan had been the world's major exporter of pyrethrum and the USA the biggest consumer. In 1937, for example, Japan exported 8,705 tons of flowers, of which the USA took 7,780 tons. During the 1930s Kenya began to emerge as a competitor; the chrysanthemum flower that yields pyrethrum was first grown in the British colony in 1931 and by 1935 a group of European growers from the Nakuru area had begun exporting the flowers they had cultivated.[20] By 1938, Kenya was exporting 1,691 tons annually, primarily to the United States for incorporation into commercial insecticidal products. The prospect for Kenyan producers was considered good; their flowers fetched a better price on the market

[16] Russell, *War and Nature,* 122-123.
[17] Gordon Harrison, *Mosquitoes, Malaria and Man: A History of the Hostilities since 1880* (London: John Murray, 1978), 209.
[18] Harrison, *Mosquitoes, Malaria and Man*, 210.
[19] Ibid., 214-15.
[20] Trustham Frederick West, "The history of the African pyrethrum industry," *Journal of the Royal Society of Arts* 107, no. 5034 (1959): 423-41.

than those of the main competitor, Japan, as they contained a higher concentration of active pyrethrins (1.3 percent, compared to 0.9 percent).[21]

The establishment of Kenya as a producer of pyrethrum before the war meant that the end of Japanese exports in 1941 did not leave the Allies in a position in which they had no access to a key material. Significant anxiety about the availability of pyrethrum did not, in fact, arise until the summer of 1942, as fighting increased in North Africa and the Middle East. Britain realised that securing pyrethrum from Kenya meant negotiation with the USA, whose firms had been the principal purchasers of East African pyrethrum before the war. The problem for Britain was not one of identifying a source of an important raw material, so much as making sure that the available supply was directed to meeting the needs of its fighting forces. While the USA became focused on ensuring producers of pyrethrum in Kenya increased the supply of flowers, Britain became increasingly concerned about whether supplies of the insecticide were being allocated according to military demand.

Several factors helped in the gradual construction of the pyrethrum problem from June 1942. In Britain, concern was prompted by an increase in demand for the material as greater numbers of troops were deployed to the Middle East, and shortages of other insecticides, notably derris, became apparent.[22] Edward Mellanby, the Secretary of the Medical Research Council (MRC; the civil body responsible for medical research in Britain), wrote to John Anderson of the War Cabinet to convey the view that calculations regarding the needs of the Service Departments for insecticides needed to include future deployments to "malarious areas" such as Burma or West Africa. In addition, demand was expected to increase further with the introduction of a pyrethrum-based repellent cream that had been developed for troops in forward areas, who slept out in the open.[23] Britain had not previously been a big consumer of pyrethrum, importing only 250 tons in 1937, compared with 8,969 tons by the USA.[24] The country now faced a substantial increase in demand to meet the needs of the military, in addition to the pyrethrum requested for civilian public health in Britain's tropical colonies, the elimination of bed bugs and cockroaches at home, use in sheep dips and orchards, and the protection of produce on ships and wharves. In addition, by the autumn of 1942, British officials had added the not inconsiderable needs of the Indian Government to the total anticipated demand, along with the military (and some civilian) requirements of Australia, South Africa and New Zealand.

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[21] West, "African pyrethrum industry," 433.

[22] Edward Mellanby to the Lord President, 4 June 1942, FD 1/5977, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom.

[23] Ibid..

[24] Insecticides for Service Use with Special Reference to Pyrethrum, Report by Ian Heilbron, February 1943, FD 1/5977, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom.

These early investigations of Britain's pyrethrum position in the summer of 1942 generated consternation amongst some officials when it emerged that Britain was in fact dependent upon the United States for access to Kenyan pyrethrum. This should not have been surprising since American companies had purchased the bulk of the crop before the war, and contracts were in place for the purchase of the future harvest. Kenyan flowers were exported to the USA where firms, such as Standard Oil, extracted pyrethrins from the raw flowers (or from processed pyrethrum powder). This pyrethrum extract was being shipped from the US to meet the needs of Britain's Service Departments. After some confusing communications between the two nations, the American authorities agreed to provide British forces, through lend/lease, with sufficient pyrethrum to cover the Suez area requirements until 30 June 1943.[25]

These discussions produced two broader conclusions on the British side. One was that the output of pyrethrum flowers from Kenya only covered about two-thirds of total anticipated requirements, leading the Colonial Office to urge that production was increased, "to a maximum."[26] The second conclusion amongst British officials was that there needed to be a pyrethrum allocation plan and that this should involve considerable reduction in civilian uses by the Americans. According to Ian Heilbron, a chemist from Imperial College of Science and Technology who was appointed to the Ministry of Production to oversee scientific aspects of insecticide supply, "The estimated United States' civilian, agricultural and public health consumption amounts to 2,679 tons, i.e., more than the total Service requirements of the whole of the British Commonwealth."[27]

In Britain, pyrethrum was officially declared a controlled substance in October 1942. Now, the only permitted civilian use was for the disinfestation of Ministry of Food stores and ships; essential for a country that was importing large amounts of food.[28] Britain expected the USA to introduce similar restrictions, making the argument that if most, or all, of the pyrethrum initially destined for American agriculture could be re-directed to areas where the military need was greatest, much of the sting of the apparent pyrethrum shortage could be drawn. This was a reasonable request from the perspective of London, since economy in the use of insecticides had left British housewives without chemical weapons to fight cockroaches and bed bugs and many inhabitants of the empire without protection from mosquitoes.[29]

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25 O. S. Franks to W. Gorell Barnes, letter, 3 September 1942, FD 1/5977, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom.

26 C. Carstairs, Colonial Office to R. S. Sayers, Ministry of Supply, letter, 14 December 1942, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

27 Ian Heilbron, report "Insecticides for Service Use with Special Reference to Pyrethrum," February 1943, FD 1/5977, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom.

28 Draft telegram, 22 October 1942; Emergency Powers (Defence) Raw Materials (Pyrethrum), BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

29 Handwritten note, anonymous, Ministry of Production, autumn 1942, BT 28/882, Pyrethrum.

Discussions between British and American officials on the supply and allocation issue were tense:

> These negotiations have been carried on in a most strained atmosphere. On the one hand we are arguing that the US is using the material with an extravagance which is intolerable, considering the need of the empire for anti-malaria measures. On the other hand, the US authorities (including certain politically powerful bodies) are suspicious of the good will of the East African producers.[30]

US officials believed that Kenyan farmers had been holding back their crop in the hope of a higher price, and a great deal of assurance was needed that producers were in fact doing their utmost to increase production.[31] Some compromise was reached in November 1942 by the Combined Raw Materials Board (CRMB) which declared that the entire Kenyan crop would become subject to government purchase by the UK's Ministry of Supply, that existing forward contracts between Kenyan producers and US firms would be cancelled, and that East African pyrethrum would be directly allocated on the basis of 4/5 to the USA and 1/5 to the UK, so that Britain was not relying upon the USA for access to a key "munition of war."[32]

By the spring of 1943 the supply problem was worse, however; existing stocks of pyrethrum were running down, and there were signs indicating depressed output from Kenya. In fact, expanding the East African pyrethrum supply had proven far from straightforward. In Kenya, pyrethrum had to compete for acreage with other crops, some of which—above all wheat—were more attractive to farmers, being marginally more profitable. Wheat also enjoyed greater government support: Kenyan crops supplied the Middle East, as well as ensuring an adequate local supply of food.[33] Labour, too, was a significant problem. Enlistment had considerably reduced the pool of available male labour, and those who remained preferred to work on wheat, which was less physically demanding to harvest than pyrethrum. The more arduous work of pyrethrum harvesting was thought fit for women and children, but they could not be

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General Correspondence, Part One, The National Archives, United Kingdom. On the malaria epidemic in Egypt in 1942 and its effects on the population see Timothy Mitchell*, Rule of Experts*; *Egypt, Techno-Politics, Modernity* (Berkeley: University of California Press, 2002), 22. On the wartime control of malaria in Accra see, Jonathan Roberts, "Korle and the Mosquito: Histories and Memories of the Anti-Malaria Campaign in Accra, 1942-5," *The Journal of African History* 51, no. 3 (2011): 343-65.

[30] R. S. Sayers, Ministry of Supply to J. C. Rea Price, letter, 19 January 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[31] Ibid.

[32] C. Carstairs, Colonial Office, to E. M, Bettenson, Ministry of Supply, letter, 14 January 1943, BT 28/882, Pyrethrum. General Correspondence, Part One. Decision by Combined Raw Materials Board, Decision No. 89, The National Archives, United Kingdom; Telegram to EAGON, Nairobi, 31 December 1942, CO 852/528/4, Pyrethrum: East Africa, The National Archives, United Kingdom.

[33] R. S. Sayers to J. C. Rea Price, letter, 19 January 1943; C. Carstairs, Colonial Office to R. L. Hall, Ministry of Supply, letter, 11 March 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

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conscripted.[34] Lastly, the pre-war success of Kenyan pyrethrum had conspired to limit planting prior to 1943: over-enthusiastic planting in the late 1930s and early 1940s had led the Kenya pyrethrum price to collapse, and the correspondingly poor market circa 1941 meant fewer acres were initially planted for 1942, which in turn meant a lower anticipated supply for the 1942/43 season.[35] This situation, which was already far from ideal, was exacerbated by poor rains.[36]

While debate was proceeding about how to remedy the issues affecting Kenyan production, the needs of the military continued to increase as operations expanded in areas where malaria was prevalent. Britain resumed its pressure on the United States to make allocations of pyrethrum on the basis of the number of troops in malarial areas, and to reduce its considerable agricultural usage. The spring and summer of 1943 mark the point at which a sense of crisis can be discerned:

> There is no need to stress the vital importance of pyrethrum supplies at the present time beyond saying that almost the whole of the supplies available to the non-Axis world come from [British East Africa]; that pyrethrum is the only effective anti-mosquito measure as yet known; that present supplies are insufficient to meet the minimum needs of the U.S.A. and U.K. Armies; and that in consequence practically no supplies of pyrethrum have been available for essential civilian needs.[37]

While the USA was mainly focussed on securing supplies from Kenya and some smaller producing countries, Britain continued to argue through the autumn of 1943 that the United States needed to ignore its powerful domestic farming lobby and reduce its allocation for agriculture.[38] The resolution finally came towards the end of 1943. The USA agreed to rein in civilian use of pyrethrum in response to pressure from British officials, and a new allocation ratio was introduced which was, in its first few iterations, far more favourable to the British.[39] The CRMB in Washington became the central body for handling pyrethrum distribution, with absolute numbers of exposed troops as the basic metric for determining allocations. The exact

[34] J. C. Rea Price, Colony of Kenya to R.S. Sayers, Ministry of Supply, letter, 10 March 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[35] Memorandum "Pyrethrum" by Raw Materials Department, 23 June 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[36] Memorandum "Pyrethrum," 23 June 1943 and Raw Materials Department to Colonial Office, letter, 30 December 1943, BT 28/884, Pyrethrum: Colonies, The National Archives, United Kingdom.

[37] Memorandum "Pyrethrum," 23 June 1943, The National Archives, United Kingdom.

[38] J. A. E. Smart, British Raw Materials Mission, Washington, to E. M. Bettenson, Ministry of Supply, letter, 11 October, 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[39] Secretary of State to Government of India, telegram, 24 August 1943, BT 28/883, Pyrethrum: India, The National Archives, United Kingdom; Combined Raw Materials Board, Decision no. 212, 30 November 1943, CO 852/528/4, Pyrethrum: East Africa, The National Archives, United Kingdom.

ratio was tweaked over time on the basis of changing deployments, mostly back in favour of the United States, as American commitments in the Pacific swelled. This approach remained in place for the rest of the war.[40]

Substitutes for Pyrethrum

The two most obvious strategies for tackling the pyrethrum problem—increasing the overall supply and reallocating according to military priority—were buttressed by a third, more research-oriented strategy, namely, to seek ways of making the supply of pyrethrum stretch further. There were three main areas of investigation: the search for adjuvants that could be added to pyrethrum to enhance its action; research into more efficient modes of delivery; and the evaluation of alternative materials that could take over some of the functions of pyrethrum, in repellent cream for example.[41] The need to identify synthetic materials with insecticidal qualities became most urgent in the spring and summer of 1943; the point at which British officials feared that the allocation of pyrethrum from the available supply would not meet the increasing needs of the Armed Forces. By the end of 1943, two resolutions had in fact emerged, one was the agreement by the USA to restrict its non-military uses of pyrethrum, the other was that DDT could be used as an alternative insecticide, first as a larvicide and anti-louse agent, and then against adult mosquitoes.

Before the spring of 1943, when scientific investigation on insecticides came under the coordination of one single body at the Ministry of Production, research in Britain was carried out by a number of laboratories operating under different government departments and research councils. The main centres of research related to Service needs were at the London School of Hygiene and Tropical Medicine (LSHTM), under the medical entomologist Patrick A. Buxton, and at Imperial College of Science and Technology under James Watson Munro.[42] The key link between civilian research institutions and the Armed Forces came through the Entomological Sub-Committee of the MRC's Military Personnel Research Committee. The Entomological Sub-Committee was created in January 1942 to study the issue of insect control in warfare and make recommendations to the Services, mainly through Major General David Turnball

[40] Oliver R. McCoy, "War Department Provisions for Malaria Control," in *Preventive Medicine in WWII: Communicable Diseases, Medical Department United States Army*, eds. Ebbe Hoff and Phebe Hoff, vol. VI (Washington: Office of the Surgeon General Department of the Army, 1963).

[41] Application for a grant by P. A. Buxton, 13 November 1942, FD 1/5977, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom.

[42] FD 1/6448, Entomological Problems Sub-Committee (Military Personnel Research Committee): Constitution and Members, The National Archives, United Kingdom.

Richardson, the Director of Hygiene at the War Office, who sat on both the Entomological Sub-Committee and the War Office Committee on Supply of Pyrethrum.[43]

In June 1942 the Ministry of Supply reported to the War Office Committee on Supply of Pyrethrum that the insecticide situation was forecast to be difficult. As Britain began negotiating with the USA over the pyrethrum position, and issued instructions to East Africa to increase production, the Pest Infestation Laboratory of the Department of Scientific and Industrial Research (DSIR) began investigating adjuvants that could cut down the amount of pyrethrum needed in anti-mosquito sprays. The British army mosquito spray combined pyrethrum with kerosene and was applied to the interiors of buildings, tents and aircraft. Pyrethrum-based sprays were valued for their potency in killing insects, and, in particular, their rapid "knock-down" effect in which they instantly stopped insects in their tracks; a visual demonstration of efficacy that promoted confidence in products, and encouraged use.[44] Pyrethrum was unique amongst the chemicals available for insect control in causing the rapid paralysis of insects before death, prompting the comment in 1943 that, "there is no other material which can do this and consequently there is no substitute for pyrethrum."[45]

Potential adjuvants fell into two types: substances that did not have any insecticidal action but enhanced the potency of pyrethrum (certain oils, such as sesame oil, fell into this category) and materials that did kill insects; both could be used to reduce the percentage of pyrethrum in the spray. It was suggested that the army mosquito spray be modified to include Lethane 384.[46] Lethane 384 was a thiocyanate insecticide that killed insects but was considered inferior to pyrethrum as it did not knock down mosquitoes flying in the air.[47] It had been combined with pyrethrum as a well-established ingredient of fly sprays such as "Flit" before the war.[48] Lethane 384 was manufactured in the USA by the Rohm and Haas company, however, it was

[43] FD 1/6448, Entomological Problems Sub-Committee, The National Archives, United Kingdom.

[44] Ian Heilbron, report "Insecticides for Service Use with Special Reference to Pyrethrum," February 1943, FD 1/5977, The National Archives, United Kingdom.

[45] Note on pyrethrum, 16 January 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[46] J. H. Burn, note to A. King, Ministry of Supply, 12 February 1943, FD 1/5977, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom; for a very good discussion of the importance of substitutes in chemistry see Matthew Paskins, "One of These Things is Just Like the Others: Substitutes as a Motivator in Eighteenth Century Chemistry," in *Theory Choice in the History of Chemical Practices,* eds. Emma Tobin and Chiara Ambrosio, 55-70 (Switzerland: Springer International, 2016).

[47] Note on pyrethrum, 16 January 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[48] Minutes of a meeting held at the War Office to discuss the use of insecticides and the effect of supply problems on policy, 23 June 1942, CO 852/460/11, Commodities. Pyrethrum: Kenya, The National Archives, United Kingdom.

not certain that supplies of this material could be secured.[49] Existing quantities of Lethane 384 in Britain were being retained by the Ministry of Health for use against head lice.[50]

In October 1942, in the face of renewed anxiety about allocations of pyrethrum, Buxton at LSHTM received a grant to investigate ways of reducing the pyrethrum content of mosquito sprays, and he took over the work that was being done by the DSIR on adjuvants.[51] Buxton and colleagues at LSHTM also carried out research into materials that could substitute for derris in army louse powder as this material too was proving increasingly hard to secure. Buxton recommended another thiocyanate, lauryl thiocyanate, as an alternative ingredient in AL63.[52] This chemical was known to cause skin irritation, however, which made it unsuitable for use in repellent creams or for the impregnation of clothing.

Research into both adjuvants and substitute insecticides was further ahead in the USA and in November 1942 a request was sent by Britain for information. Early in 1943, Britain received news that the Laboratory of the Bureau of Entomology and Plant Quarantine in Orlando had been screening hundreds of synthetic compounds and now recommended three for use as repellents by the US army—Indalone (butopyronoxyl), DMP (dimethyl phthalate) and Rutgers 612 (2-ethyl-l, 3-hexanediol).[53] Richardson, as Director of Hygiene at the War Office, obtained samples for testing in the field in West Africa, and in spring 1943 it was recommended that Britain order DMP from American manufacturers for use as a mosquito repellent. The USA also promoted the use of sesame oil to economise on pyrethrum in sprays, saying that the oil reduced the quantity of insecticide required by 50%.[54] Sesame oil was subsequently adopted as an adjuvant in British army-issue pyrethrum sprays in 1943.[55]

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[49] Meeting at the War Cabinet to discuss Heilbron's report, 24 February 1943, FD 1/577, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom.

[50] Treasury Inter-Service Committee, Purchase of pyrethrum and other insecticides, 1943/44. Draft, 22 September 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[51] FD 1/6448, Entomological Problems Sub-Committee, The National Archives, United Kingdom; P. A. Buxton to A. Landsborough Thomson, letter, 9 November 1942, FD 1/5977, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom.

[52] Ian Heilbron, report "Insecticides for Service Use with Special Reference to Pyrethrum," February 1943, FD 1/5977, The National Archives, United Kingdom; P. A. Buxton to I. Heilbron, letter, February 1943, FD 1/5977, Research on Pyrethrum (Insecticide): Minutes of War Cabinet Meetings, 1941-1943, The National Archives, United Kingdom.

[53] Note on pyrethrum, 16 January 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[54] Ian Heilbron, report "Insecticides for Service Use with Special Reference to Pyrethrum," February 1943, FD 1/5977, The National Archives, United Kingdom.

[55] Raw Materials Department to Colonial Office, letter, 23 October 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

Faced with the seeming reluctance of the United States to curtail its domestic consumption of pyrethrum and concern that scientific recommendations on substitutes were being ignored by the armed forces, Heilbron was invited formally to assess the insecticide situation in February 1943. His report began with firm reiteration of the centrality of pyrethrum, "Of all the materials both natural and synthetic, which have been found to kill biting insects, pyrethrum is by far the most effective." He went on to note that pyrethrum offered the best protection against mosquitoes, was effective against lice, and was the only material that could be safely sprayed in the vicinity of stored foodstuffs.[56] Heilbron recommended the creation of an Anglo-American Commission (subsequently the Pyrethrum Mission) to allow regular in-person exchange of information between the two countries, and a new committee in Britain to speed up the adoption of adjuvants and substitutes by the fighting forces. The result was the creation of an Inter-departmental Coordinating Committee on Pyrethrum (later Insecticides) to translate technical recommendations into actions, with a Pyrethrum Development Panel (later Insecticides Development Panel) formed in March 1943 that included Heilbron, Buxton and Munro, and which coordinated research.

From May until September 1943 the discussion about possible substitutes for pyrethrum increasingly came to focus on one particular substance, initially called by the proprietary names "Neocid" or "Gesarol" and from August increasingly known as "DDT" A report by Heilbron and Alexander King circulated in August 1943 noted that of all the substances that had been evaluated in the USA and UK as possible substitutes for some of the pyrethrum content of mosquito spray, "only three need to be mentioned: Lethane, Thanite and DDT."[57] The comment on DDT was that it produced a high kill in laboratory tests but no knock down effect. In combination with pyrethrum, however, it was deemed "the most promising" of all the substitutes under consideration for a spray against mosquitoes. [58]

DDT had first been brought to the Allies' attention in early 1942 by the Swiss chemical company J.R. Geigy A.G. who applied for patents in London for its products in 1941 and 1942.[59] The approach by the firm was on several fronts—to the British via the legation at Berne

[56] Ian Heilbron, report "Insecticides for Service Use with Special Reference to Pyrethrum," February 1943, FD 1/5977, The National Archives, United Kingdom.

[57] Ministry of Production, Pyrethrum Development Panel, Appreciation by the Chairman of the Present Position with regard to insecticides and repellents for Service use, 4 August 1943, MAF 130/21, Insecticide Development Panel, Ministry of Production (known as the Pyrethrum Development Panel, Mar-Oct 1943): meetings 19 and 20, The National Archives, United Kingdom.

[58] I. Heilbron and A. King, reports, Ministry of Production, Pyrethrum Development Panel, Present position with regard to insecticides and repellents for service use, 4 August 1943, FD 1/5978 Research on Pyrethrum (insecticide), The National Archives, United Kingdom.

[59] Henry Imrie & Co to Geigy Company, letter, 21 February 1950, T166/128/2, J. R. Geigy SA and Geigy Company Ltd: Dichlorodiphenyltrichloroethane (DDT) as an insecticide and improvements, 1942-1954, The National Archives, United Kingdom.

and through Geigy's UK subsidiary.[60] Geigy provided two products for evaluation: Gesarol, targeted at agricultural applications, and Neocid, formulated as a product that controlled lice. If it could be proven effective, Neocid seemed to offer a compelling substitute for pyrethrum in louse powder, and by May 1943 DDT had been incorporated by the USA in its MYL dust.[61]

DDT was tested extensively in the summer and autumn of 1943 in America and Britain, for its efficacy against mosquitoes and lice in a variety of formulations of sprays and dusts, and to assess if it posed any risk to human health.[62] Work was done at LSHTM against mosquitoes to determine what concentration of DDT and pyrethrum were most effective in combination as a spray. In these experiments DDT concentrations were compared with pyrethrum for their ability to disable and then kill mosquitoes; in these tests pyrethrum was designated the Official Test Insecticide (OTI), and DDT was the comparator product.[63] Laboratory investigations were accompanied by experiments in the field in North and West Africa and India. Initial deployment sometimes revealed unwelcome side-effects. In October 1943 after sprays had been in use in barracks it was reported that "when DDT is dissolved in kerosene and used as a fly spray it results in bad headaches which, in some instances, makes men incapable of work."[64] The absence of a knock-down effect also continued to inform the impression of DDT as a chemical with limitations:

> The shortage of pyrethrum has inevitably greatly quickened the development of synthetic insecticides and one in particular (DDT) shows very considerable promise and is being incorporated in Service sprays. It is not, considered, however, that these synthetics are likely to oust pyrethrum completely or if they do, to do so very rapidly. In fly sprays, pyrethrum provides a more rapid knockdown of the insects than any material now known and is likely to be used in conjunction with synthetics although the final pyrethrin concentration used in such composite sprays may be less than it now is.[65]

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60 "Now it can be told," press release from Geigy Company Inc, 31 May 1944, T166/128/2, J.R. Geigy SA and Geigy Company Ltd: Dichlorodiphenyltrichloroethane (DDT) as an insecticide and improvements, 1942-1954, The National Archives, United Kingdom; T. F. West and G. A. Campbell, "DDT" in *The Industrial Chemist*, September 1944, AVIA 22/1605, Impregnation of Textiles with DDT Insecticide, The National Archives, United Kingdom.

61 "Now it can be told," press release from Geigy Company Inc, 31 May 1944, T166/128/2, The National Archives, United Kingdom.

62 Minutes of the Third Meeting of the Pyrethrum Development Panel, 4 June 1943, and other meetings in this file, BT 28/887, Ministry of Production: Pyrethrum Development Panel, The National Archives, United Kingdom. On the toxicological work see Davis, *Banned,* chap. 2.

63 Minutes of the Third Meeting, 4 June 1943, BT 28/887, Ministry of Production: Pyrethrum Development Panel, The National Archives, United Kingdom; Summary of information on insecticides and repellents, Office of the Scientific Advisers (Chemistry), Ministry of Production, 1 January 1945, CO 927/7/5, Insecticide '666': trial use in Colonies, The National Archives, United Kingdom.

64 E. M. Bettenson, Ministry of Supply to Lt Col Capon, letter, War Office, 21 October 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

65 Notes on Pyrethrum cultivation in East Africa. c. October 1943, BT 28/886, Pyrethrum, East African

The initial object of investigations by the US and UK in 1943 was to determine the value of DDT as a "potential substitute for pyrethrum."[66] The new insecticide was still evaluated at this point as part of the bigger project of finding ways to conserve supplies of pyrethrum. One argument for combining DDT and pyrethrum together in mosquito spray was that this released pyrethrum for use in repellent creams. In July 1943 the comment was, "If the DDT formula with only 0.2% pyrethrins proves acceptable then I can believe that during 1944 we shall have some pyrethrins to spare above the spray requirements."[67] Similarly, the success of experiments in the field that had shown DDT with kerosene was an extremely effective larvicide, combined with its utility as a louse powder and as a component of mosquito spray, meant that by December 1943, the Ministry of Supply was stating that "DDT had proved its value, with the result that there was now good prospect that 5000 tons of pyrethrum could be made to go as far as 10,000 tons in the past."[68] DDT was important at this point, then, not for its potential for *supplanting* pyrethrum, but rather for maintaining its relevance.

On the British side (quite possibly more than on the US side) we can perceive some reluctance to admit the possibility that the advent of DDT might herald the decline of pyrethrum after Britain had gone to such lengths to persuade Kenyan producers to increase their crop. When the East African Governors Conference asked if there were any alternatives to pyrethrum in January 1944, the Ministry of Supply responded:

> Although we are greatly impressed by the insecticidal potentialities of DDT and although other insecticides are good used against certain insects, eg house-flies, we can certainly say at present that there is nothing to compete with pyrethrum as a combination of the following very desirable properties:
> 1. Speed of effectiveness (ie "knockdown"), combined with final kill;
> 2. Range of insects against which it is effective;
> 3. Complete safety in use at the necessary concentrations.[69]

East African producers of pyrethrum were given a production target for 1944 of 20,000,000 lbs of flowers, equivalent to just over 8,900 imperial tons.[70] Pyrethrum was not just consumed

Governors Conference, The National Archives, United Kingdom.

66 Confidential note on pyrethrum, 23 September 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

67 Raw Materials Department to War Office, letter, 17 July 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

68 Minutes of meeting at the Ministry of Supply on the purchase of pyrethrum and other insecticides, December 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

69 Ministry of Supply, letter, January 1944, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

70 Ministry of Supply to Washington, draft telegram, November 1942, BT 28/884, Pyrethrum: Colonies, The National Archives, United Kingdom.

by Britain in the period after the advent of DDT; imports of pyrethrum flowers into the USA in 1945 exceeded those of 1943 and 1944.[71]

The fact that DDT was not immediately seen as a replacement for pyrethrum, making the older insecticide obsolete, but rather a chemical that could make pyrethrum supplies go further, resulted in part from the context in which DDT was first tested. Britain and America had been engaged in a complex and difficult logistical and diplomatic process to secure allocations of pyrethrum, and the unique qualities of this material had been reiterated multiple times; its special status in Britain was made official when it was declared a controlled substance. The process by which DDT supplanted pyrethrum (and other insecticides) was one in which the new chemical was gradually reinvented from a substitute material, in which context it was evaluated in comparison with another substance, to being an insecticide in its own right and the exemplar by which others were judged. The idea of DDT as a substance that was superior to existing insecticides, even without a knock-down effect, came gradually through the rounds of testing in laboratories, field trials in West Africa and India, and reports of the experiences of the army as they incorporated the chemical into their malaria control protocols. Tests in the field revealed that DDT was a more effective larvicide than Paris Green against many species of mosquito.[72] Experiments showed that it did not cause skin irritation as some other synthetic materials had done, and it could be used to impregnate the clothing provided to soldiers. Most importantly, as have been noted by historians, the insecticidal effects of DDT were very long lasting. DDT was introduced in place of derris in the third iteration of the British Army louse powder; AL63 Mk III.

By early 1944 DDT was in production by Geigy in Britain. Orders were initially small, amounting to around 200 tons.[73] The position changed in March 1944 when an order of 280 tons were placed by South East Asia Command (SEAC) for mosquito control.[74] The volume of output that was now anticipated was around 1,000/2,000 tons per annum.[75] Two chemical defence factories previously assigned to the production of "antiverm," a chemical

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[71] "Imports of Pyrethrum," *Journal of International Economy*, 12 January 1946: 27. It is not clear from the archival materials available on the British side what the USA was doing with this pyrethrum—it is quite possible that it was still being incorporated into US Army mosquito bomb and sprays because of its knock-down action.

[72] Meeting to consider requirements of DDT, 27 March 1944, AVIA 22/2056, DDT Production, The National Archives, United Kingdom; Note of a meeting on DDT held at the War Office, 1 and 3 March, 1944, BT 28/896, DDT General, The National Archives, United Kingdom.

[73] Minutes of meeting at the Ministry of Supply on the purchase of pyrethrum and other insecticides, December 1943, BT 28/882, Pyrethrum. General Correspondence, Part One, The National Archives, United Kingdom.

[74] War Office to Ministry of Production, note, 21 March 1944, BT 28/896, DDT General, The National Archives, United Kingdom.

[75] Report on DDT, April 1944, BT 28/896, DDT General, The National Archives, United Kingdom.

used for impregnating clothing and in ointments as protection against mustard gas, were swiftly repurposed to produce DDT.[76] In April 1944 the Inter-Departmental Coordinating Committee on Pyrethrum formally expanded its remit to include DDT, and were joined by the Director-General of Explosives at the Ministry of Supply who oversaw the manufacturing of DDT in Britain.[77] A shift towards ensuring that adequate supplies of DDT were being produced by chemical factories in Britain did not mean, however, that the requirement for pyrethrum had come to an end. Pyrethrum was a constituent of British anti-mosquito spray for the remainder of the war, in combination with DDT.[78]

DDT as More Than a Substitute

DDT offered two main advantages from the British perspective. One was that once some initial issues of raw materials and labour had been addressed, Britain's domestic chemical industry was able to manufacture sufficient DDT to meet the needs of its armed forces without great issue. The eventual widespread use of DDT depended upon this ability of Britain and America to produce it at scale. This was not something that could be taken for granted. Yet Britain *was* able to produce DDT at scale: more than 7,000 tons by the end of the war. This fell slightly short of the full, and by now, lavish demands being placed by British forces and authorities around the world, but still equated to the possibility of use—in individual mosquito sprays, aerial distribution, larvicide, louse powder, impregnated clothing and so on—on a significant scale. That Britain was able to institute production of a novel synthetic chemical in this way bears witness to its latent industrial capacity. Multiple firms were contracted to participate in production. Geigy, naturally, were first to begin production, but by no means the largest contributor overall: ICI, although wedded to their own substitute insecticide, 666/BHC, accounted for around 30.6% of Britain's overall wartime DDT production.[79] The adoption of DDT meant that Britain was no longer dependent upon imports of pyrethrum and therefore at the mercy of the rains in Kenya or the deliberations of the CRMB. The turn to DDT meant the assumption of greater direct control by Britain over its supply of insecticides.

The extensive laboratory and field experiments that were done with DDT in 1943 and 1944 showed it to be an extremely versatile and effective material for insect control. We need to

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[76] Note on DDT production, 22 May 1944, AVIA 22/2056, DDT Production, The National Archives, United Kingdom.

[77] Ministry of Production to J. W. Armit, Director General of Explosives, Ministry of Supply, letter, 5 April 1944, AVIA 22/2056, DDT Production, The National Archives, United Kingdom.

[78] Summary of Information on Insecticides and Repellents, Office of the Scientific Advisers (Chemistry), Ministry of Production, 1 January 1945, CO 927/7/5, Insecticide '666:' trial use in Colonies, The National Archives, United Kingdom.

[79] G. M. Phillips to W. A. M. Edwards, Chemical Control Board, letter, 30 September 1944, AVIA 22/2056, DDT Production, The National Archives, United Kingdom.

avoid the assumption, however, that DDT was far, far more toxic than any alternative material (that it produced a quicker, higher, or a more broad spectrum insect kill), as the claim that it was the "atomic bomb of insecticides" seems to suggest.[80] DDT killed the larvae of a greater variety of mosquito species than Paris Green when used as a larvicide on standing water, and the decision to stop using the latter and move over entirely to DDT was made in March 1944.[81] DDT did not, however, necessarily give a higher kill than pyrethrum when tested against adult mosquitoes (its efficacy in fact varied according to the species of mosquito and the age of the insect).[82] The quality that most distinguished DDT from the natural insecticides in the field of mosquito and lice control was its long-lasting nature. The fact that the toxic effects of DDT did not dissipate for several weeks after application made it an extremely potent material.[83] Grasping exactly why this was so significant in wartime requires us to consider the way in which insecticides were used. Pyrethrum and DDT were just one part of a larger array of disease control practices deployed by the armed forces and were more or less important, depending upon the context.[84] Despite the grand claims that have been made about the use of DDT in WWII, the chemical never single-handedly saved the lives of millions of soldiers or civilians from the threat posed by malaria or typhus.[85]

This is well illustrated by the first widely publicised deployment of DDT when it was used to control an outbreak of typhus in Naples over the winter of 1943-44. British and American troops in Italy had been given protection against typhus by a vaccine, but the concern in the winter of 1943 was how to contain the spread of typhus amongst the civilian population. Up to a million people in the Naples area were struggling in the face of inadequate food and water supply, poor sewage, and the spread of disease through overcrowding in the air-raid shelters and caves being used by the population. The typhus control campaign launched by America and Britain used a 10% formulation of DDT that was applied with a blower up to the sleeves, trousers and skirts of people and down collars so that the dust penetrated the layers of clothing, killing the lice that spread disease. Yet, beyond the headline claim in the

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80 Dunlap, *DDT,* 3.

81 Meeting to consider requirements of DDT, 27 March 1944, AVIA 22/2056, DDT Production, The National Archives, United Kingdom; Note of a Meeting on DDT Held at the War Office, 1 and 3 March, 1944, BT 28/896, DDT General, The National Archives, United Kingdom.

82 V. B. Wigglesworth, interim report on anti-mosquito sprays LSHTM, 11 August 1943, MAF 130/21, Insecticide Development Panel, Ministry of Production (known as the Pyrethrum Development Panel, Mar.-Oct. 1943): meetings 19 and 2, The National Archives, United Kingdom; Davis, *Banned*, 44.

83 The significance of the discovery of the persistence of DDT for US scientists is well explored by Davis, *Banned*, 42-3.

84 Of the existing accounts of insecticides in WWII, Edmund Russell has done the most to contextualise insecticides in the bigger picture of disease prevention amongst US forces, Russell, *War and Nature*.

85 The claim that DDT saved the lives of millions is made by Dunlap, *DDT*, 7; Kinkela states that DDT "single-handedly" ended the typhus epidemic in Naples, Kinkela, *DDT and the American Century*, 37.

press that the new insecticide had brought an epidemic to a halt in the middle of winter,[86] more detailed descriptions of the campaign, produced by doctors on both the British and American side, noted that DDT was used *after* pyrethrum dust had already done a great deal to bring the situation under control.[87] The same accounts often placed the greatest emphasis on the introduction of "intensive and extensive case finding" in which contacts of individuals with disease were systematically tracked down and treated.[88] The fact that the campaign was a triumph of organisation that employed new methods of tracking infestation across a population were side-lined in popular accounts, however, in favour of celebrating the wonders of DDT.[89] The press used DDT to promote the idea to a domestic audience that America and Britain were bringing the most modern tools of medicine to the aid of civilian victims of war and it was also used to reassure the large numbers of Allied troops stationed in the vicinity that they would not be witnesses to an uncontrolled epidemic of a deadly disease.[90] DDT had a function in maintaining morale at home and abroad.

The more detailed accounts of the Naples campaign produced by the British and American medical personnel, who oversaw the control effort, offer an important reminder that neither pyrethrum nor DDT were the *sole* means of malaria and typhus control for Allied forces, even if some of the more hyperbolic celebrations of DDT after the end of the war suggested that this was the case. They also offer us an insight into why the remarkable persistence of DDT, in which one application had lasting toxic effects on insects, gave it a special role as part of a larger array of disease control practices. In March 1944, General Richardson reported, "in a native prison in North Africa prisoners were infested to an average of 3000 lice per man. Impregnated shirts gave complete control for 84 days." Similar long-lasting effects were found in tests of louse powder. Referring to the Naples outbreak, Richardson reported that one application of DDT with the blower gave protection against re-infestation for 16 days.[91] Clearly, the fact that the effects of DDT lasted far, far longer than those of any other chemical, made it a highly valuable tool for the control of disease amongst a civilian population in wartime. The use of DDT did not require individuals to attend for multiple treatments, adhere to instructions

86 "Battle with typhus in Naples," *The Times*, January 15, 1944, 3; "Protecting soldiers against typhus: shirts impregnated with a new insecticide," *The Manchester Guardian*, August 2, 1944, 6.

87 Russell, *War and Nature*, 127.

88 Lt col. Charles M Wheeler, "Control of Typhus in Italy by Use of DDT," *American Journal of Public Health* 36 (1946):119-29; Herbert D. Chalke, RAMC, "DDT: Experiences of its use during the Italian Campaign," February 1946, WO 220/414, DCC Typhus in Naples: Steering Report, The National Archives, United Kingdom.

89 "Fight against typhus in Naples," *The Times*, February 21, 1944.

90 Typhus Order, *Union Jack*, 10 January 1944, WO 220/414, DCC Typhus in Naples: Steering Report, The National Archives, United Kingdom. For the best account of the press of American coverage of the Naples control programme, see Kinkela, *DDT and the American Century*, chap. 2.

91 Meeting to consider requirements of DDT, 27 March 1944, AVIA 22/2056, DDT Production, The National Archives, United Kingdom.

for a course of medication, or even strictly observe hygiene practices. It removed the need for more than one moment of contact between medical staff and individual (an individual who did not even need to remove any clothing), or the need for an extended period of supervision and compliance.[92] In the complex and shifting conditions of liberated Europe, where typhus could spread easily amongst transient populations who had little access to washing facilities or clean clothes, the power of DDT lay in the fact that it offered an extended period of protection against typhus after a one-off application.

The persistence of DDT also made it ideal for use by troops on the move and on the front line, who did not have the time or focus to observe the normal protocols of army malaria and typhus control. In the case of typhus, effective prevention and control was typically wrought through a combination of good hygiene practices, the provision of a vaccine, and the use of insecticides in the form of a dust applied to clothing. Normally, British troops were exhorted to keep their hair short, wash frequently, avoid sharing blankets and to submit to regular inspection. A Royal Army Medical Corps Field Hygiene Unit brought mobile baths to troops and a disinfestor that cleaned blankets.[93] Issuing a soldier with a DDT-impregnated shirt that gave protection against lice for many weeks was an ideal solution to the problem of avoiding the spread of lice when under the chaotic conditions of battle. Such shirts were issued to British forces in preparation for D-Day in 1944.[94]

Similarly, in the case of malaria control, the British Army had well-established methods for preventing disease amongst troops, the priorities being the regular use of mepacrine tablets by all personnel, and during the Burma campaign, the operation of special field hospitals in forward positions to rapidly treat malaria and return men to the frontline.[95] Mark Harrison suggests that when British malaria control approaches worked well, they were a testament to the priority that was given to preventive medicine by combatant officers, who took medical advice seriously and required their troops to adhere to anti-malaria precautions such as taking mepacrine, using mosquito nets and wearing long trousers at dusk.[96] DDT was important when routine malaria prevention measures were more difficult to enforce, or were not sufficiently well implemented, as had been the case during the invasion of Italy.[97] The treatment of ditches with DDT as a larvicide, spraying buildings in forward areas and aerial spraying (as carried out in the Kabaw

[92] Notes on experience with powders in the control of typhus in Italy, 1943 to 1945, WO 220/414, DCC Typhus in Naples: Steering Report, The National Archives, United Kingdom.

[93] *The Louse* by War Department (Periscope Film LLC archive, 1942) filmstrip, 20 min., https://archive.org/details/22744TheLouse, accessed November 4, 2022.

[94] Secretary, Interdepartmental Coordinating Committee on Insecticides, note, 1 September 1944. FD 1/5978, Research on Pyrethrum (Insecticide), Reports, The National Archives, United Kingdom.

[95] Harrison, *Medicine and Victory.*

[96] Ibid.

[97] Ibid., 145.

Valley in Burma in June-December 1944) were important in keeping mosquito populations down when troops were advancing without good shelter, or the time to organise camps and properly supervise preventive measures. We should remember, however, that British army-issue anti-mosquito sprays continued to use DDT and pyrethrum in combination until the end of the war. The introduction of DDT did not make existing malaria control approaches obsolete nor did it bring the demand for pyrethrum to an end. Greater care is needed when reference is made to the idea that DDT was technically superior to any alternative.[98] The chemical was not faster acting than pyrethrum, nor necessarily more toxic (although it was much more toxic than Paris Green), but it did retain its potency for far longer than any of its predecessors. This was one important reason that DDT, became, late in the war, the most prominent, widely-deployed insecticide by Allied forces.

Conclusion

Claims about the revolutionary character of DDT were largely constructed in the wake of the Second World War.[99] Historians have noted that the image of DDT was a crafted one; they tell how *Time* magazine, for example, celebrated the supposed scientific superiority of the United States by promoting the idea that Allied victory was due to a number of new technologies including DDT and the atomic bomb.[100] Despite recognition of the propaganda value of these claims about DDT, historians have not necessarily sought to recontextualise the chemical in relation to other insecticides used during the war. The lack of engagement with a wider landscape of insect control measures gives the misleading impression that without DDT Allied forces and the civilians they encountered would have had little protection against malaria and typhus. While much scholarship suggests older insecticides were not available, other work notes that pyrethrum was used in the early years of WWII but does not let that fact disturb a narrative of war and insect-borne disease that is centred on the role of DDT.

We could conclude that one consequence of failing to fully engage with the myth-making of the past is a failure to recognise the significance of pyrethrum (and to a lesser extent, derris and Paris Green) for the Allies during the Second World War. A considerable amount of work was done to ensure a continued supply of pyrethrum after 1941—by officials in the USA and Britain, by members of the Armed forces, by East African governments and the farmers and workers in their territories, and by scientists who sought to extend supplies of the material. Pyrethrum was a highly valued material, a "munition of war;" sought not just by the military but also in high demand by American farmers whose reluctance to give up this favoured insecticide caused

[98] Perkins, "Reshaping," 10.
[99] Kinkela*, DDT and the American Century*, 7.
[100] Davis, *Banned*, 38; Kinkela, *DDT and the American Century,* 40.

considerable consternation on the other side of the Atlantic. If we wish to single out materials that were perceived as significant for the ability of the Allies to wage war, then pyrethrum has a claim that is not markedly different to that of DDT. However, if we wish to avoid the tendency to endow technologies with disproportionate effects, then we have to consider that neither material can be said to have been single-handedly responsible for saving lives. Clearly heroic narratives of pyrethrum will not tell us the full story of why British military hygiene could prove so effective. De-centring DDT means recognising the significance of the planning and organisation that worked to preserve the health of the armed forces. It means recognising the importance of the cooperation between specialist medical personnel and combatant officers, who took disease seriously and designed and implemented effective systems for disease control. Apart from a need to consider insecticides as only one part of a bigger array of practices we should also recognise that the success of DDT as a means of insect control came through the way it was easily incorporated into technologies and arrangements for disease prevention that were already up and running: special malaria control units that applied larvicide, the Flit gun for spraying mosquitoes, the issue of personal louse powder. DDT succeeded because the systems that had been developed for the deployment of pyrethrum, Paris Green and derris—organisational, logistical and technical—were so effective.

Looking at the bigger picture of insecticide supply and deployment shows just how many options were available to Britain and America after pyrethrum supplies from Japan came to an end. As David Edgerton has pointed out, rich nations in the Second World War were nations with economic flexibility.[101] At the start of the war Britain imported small quantities of pyrethrum. As demand increased through the deployment of troops to areas where malaria and typhus were prevalent, Britain found itself in a position where it needed to rapidly increase its supply. That Britain was able to secure a greatly increased supply, indirectly through the US at first, and then directly, demonstrates both the importance of its relationship with the United States and its power over colonial production. Later in the war it moved over to domestic manufacturing of the synthetic alternative, DDT. Britain and the USA then had both the ability to direct the supply of natural materials from overseas and then institute and expand the production of organic chemicals at home. This is the story of insecticides in World War II from the Allied perspective—it is a story of nations able to respond to a changing situation of supply and demand by marshalling international networks of supply, evaluating large numbers of substitutes, and deploying their domestic manufacturing capacity; it is a story of economic reach and industrial strength.

[101] Edgerton, *Britain's War Machine*; "Controlling resources."

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Competing interests

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