“Let Us Spray”[*]

The Transition to Manufactured Insecticides, 1860-1900

By James E. McWilliams

American farmers experienced an unprecedented explosion of insect attacks on their crops throughout the second half of the nineteenth century. In the midst of these outbreaks, Charles V. Riley and Leland O. Howard, two of the nation’s most prominent entomologists, drank a considerable amount of beer. “In those early days,” Howard later recalled, “entomology and beer went together.” Riley and Howard had formed the Entomological Society of Washington in 1884 and it was at their weekly meetings that they and a coterie of local entomologists—“all Teutons” Howard proudly noted—wrangled with the entomological news of the day. Contrary to Howard’s whimsical remark that the biggest choice the group faced was whether “to have light beer or dark,” the society confronted profound entomological choices that would shape the field for generations to come. Foremost among these choices was how to negotiate the chemical insecticides that began to flood the agricultural market in the 1880s as an antidote to the poison of insect infestations.

As insect pests proliferated alongside agricultural losses, so did scores of insecticides. Overwhelmed and desperate, the nation’s farmers experimented, conversed, and sought professional guidance. Howard said little about the matter in his memoirs, quipping in reference to the club that “a few glasses of beer will make a stupid remark sound witty, but there was no necessity for such stimulus . . .because all the remarks

[*] This paper is a version of a chapter from a book I am writing tentatively called *The Bug Wars: A History of Insect Control in the United States.*

were witty." But they were not witty enough to prevent Howard and Riley from having a falling out over the issue of insecticides. By 1894 the two men were running the U. S. Department of Entomology while dodging each other in the hallways. Riley, it turns out, was—like his old friend and co-editor of the *Practical Entomologist*, Benjamin Walsh—cautiously skeptical of the looming transition to chemical insecticides. But Howard, who would later call Riley's proposed alternative (biological control) a "badly based policy," was far more supportive of insecticides. The stakes were bigger than light beer or dark.[1]

Nearly fifty years after the founding of the Entomological Society, Howard would look back at his early days working under Riley and recall, "Much to my disappointment, I found that Professor Riley wished to use me . . .more as a clerk than as a scientific assistant." This was sour grapes. Howard, after all, had become the most influential American entomologist of the early twentieth century, and he had done so based in large part on his advocacy of insecticidal solutions to agricultural problems. It was his lead that farmers followed to make the United States an insecticide nation. In the face of considerable evidence against the effectiveness of insecticidal methods, and in the dim light of a promising (if under-explored) alternative, America's leading entomologists joined Howard, the U. S. Department of Agriculture, the Division of Entomology, and commercial farmers across the nation in supporting a wide range of synthetic insecticides as the terminal answer to the interminable bug wars. Howard used his influence as the nation's chief entomologist to both lead and foster this development.[2]

On the surface, this turn of events seems puzzling. Entomologists had built their profession upon a philosophy and methodology rooted in relatively conservative

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[1] Mallis, *American Entomologists*, 83
[2] L. O. Howard, *Fighting the Insects: The Story of an Entomologist* (MacMillan: New York, 1933), 29.

measures. Understanding insect life cycles, adhering to a "balance of nature" perspective, working from the premise that insects could be controlled but never eliminated, and wedded to the old belief that nature should combat nature were just a few of economic entomology's founding principles. It would seem, then, that entomologists working in the long shadow cast by the nation's first economic entomologists would find the idea that insects could be immediately destroyed with the quick application of an unfamiliar concoction to be inherently problematic. The fact that they chose to see the cup as half full, however, forces us to consider in close detail the chemical transition that characterized the bug wars in the second half of the nineteenth century. Why did Howard's preference prevail?

"science must furnish us with the remedy"

Several immediate reasons stand out as viable explanations for entomological support of the chemical revolution. First, whether they favored Riley or Howard, economic entomologists ultimately placed their loyalties where they had always placed them: squarely with the farmer. The farmer might have made some terrible agricultural decisions over the century, and the farmer might have been in large part responsible for the pest outbreaks that ravaged his crops, but he was still the entomologists' *rasion d'etre* And the farmer, of course, had suffered mightily over the last half-century. The potato beetle, the chinch bug, the Hessian fly, the San Jose scale, and swarming locusts joined thousands of other species of weevils, borers, mites, and flies to render the task of growing crops even more difficult than storage fees, transportation costs, and high interest rates had already made it. Farmers were being held hostage by their agricultural choices, and they were desperate for a quick fix, something scientific and revolutionary in nature. This is exactly what insecticides, especially ones that hucksters promoted without scruples or regulations, breathlessly promised. Entomologists thus entertained the chemical option in part because their clients, who had taken the careless leap towards monoculture and extensive farming, pressured them in their desperation to do so. Given the circumstances, entomologists were prepared to smile with guarded optimism, even if they were, as Howard admitted, "inclined to frown down the whole idea of chemical insecticides."[3]

Another reason behind entomological support for the first chemical insecticides was psychological. For all their high-profiled work with farmers, entomologists had labored for decades with minimal public, much less scientific, recognition. Their low position on the totem pole of professional status owed itself to their inherent traditionalism and unshakable reputation as eccentric "bug catchers." Entomologists were stereotyped, and often mocked, as being out of tune with cutting edge developments in the rarified realm of "pure" science. Experiments with insecticides, however, pulled the entomologist into a more prestigious fold of scientific inquiry. Testing insecticides enabled entomologists to think in broader scientific terms rather than react inductively to random agricultural problems. In a scientific atmosphere where "abstractness correlated closely with status," distance from the old venues—the family farms and homey agricultural journals—held a seductive appeal. Riley hinted at this appeal when he told the Philosophical Society of Washington that "Experiments with insecticides and appliances will . . .be intelligent and successful as the facts of chemistry, dynamics, and

[3] Adelynne Hiller Whitaker, "A History of Federal Pesticide Regulation in the United States to 1947," (Ph.D dissertation, Emory University, 1974), 12.

mechanics are utilized." Backing pesticides, in short, lent entomologists an immediate and, for many (like Howard, who felt compelled to mention that his father "was not a college man") a welcome dose of professional prestige.[4]

Politics were a critical factor as well. The contemporary political environment—one defined by a precarious combination of populist and progressive agendas—served as a welcoming context for the advocates of chemical insecticides. Progressivism, for its part, demanded that problems addressed by the federal and local governments were quantifiable by a team of "experts." Under tightly controlled conditions many insecticides delivered their blows with lightening speed and, predictably, faster concrete results were more politically palatable than delayed ambiguous ones—a political reality that Howard certainly appreciated. Pragmatism was the philosophical foundation of progressivism, and it was a philosophy that promoted "truth" as whatever "worked." Populism complemented progressivism (which is usually seen as a strictly urban movement) by urging the federal government in particular to address the needs of agriculture. We know a great deal about the populist push for reforms such as lowered interest rates and leveraged grain storage, but, as Riley the Missourian knew, the quest for insecticidal control was part of the larger populist agenda, too. These overlapping political trends provided insecticides with a welcoming context while making it difficult

[4] Charles E. Rosenberg, "Rationalization and Reality in the Shaping of American Agricultural Research, 1875-1914," *Social Studies of Science* (7) 4 (November 1977), 401; Richard Hofstadter, *The Age of Reform* Vintage: New York, 1955), 148-164; Charles V. Riley, "Recent Advances in Economic Entomology," *Proceedings of the Philosophical Society of Washington* (246th meeting), February 2, 1884, 10. Howard, *Fighting the Insects*, 3. An example of how pervasive this insecurity was comes from J. C. Neal, a Florida entomologist, who wrote, "It is very common to ridicule the efforts of practical entomologists, and belittle the results obtained by their methods of preventing or mitigating the ravages of insects." Quoted in F. H. Fowler, *Insecticides and their Application* (Boston: Wright and Potter, April 1891), 3.

for any group, much less a bunch of "bug catchers" intent on agricultural reform, to ignore the potential promise of insecticidal solutions.[5]

Finally, one must never discount hubris. Insecticides held out hope for that noble dream of comprehensively controlling the animal world. The quest for domestication, or even total dominance, over *every* aspect of the animal world dated back to the era before the nation's founding. But insects had, as Oliver Goldsmith noted back in 1795, been the most uncooperative and elusive animals thwarting that goal. Maybe that could change with insecticides? Maybe man really could dominate nature? Maybe he could bend it fully to his eager and grasping will? When a man of science could write that an ounce of a particular insecticide "will dust 28 heads of cabbage and in the course of two or three days all the worms will be killed," farmers intent on controlling their environment could not help but to prick up their ears and imagine the possibilities. Such bold declarations made the gradualism behind Riley's biological control approach appear far less attractive. Put another way, insecticides potentially fostered the ongoing transition from a "naturalistic" to a "humanistic" view of the environment. This was a transition marked by the demise of the idea that there were "intrinsic limits to [humans'] manipulative powers" and the rise of the countervailing notion that "man is part of the biosphere and that he can be master of it." The quest for mastery was a seductive one, and it surely

[5] One example of the imperative to bring the government to bear on national problems came from Seaman A. Knapp, professor of agriculture at Iowa State, who in 1877 wrote that the "magnitude" of agriculture's problems "is too great for individual enterprise, or even associated enterprise . . .national government is the only party which has the means to carry out successful termination investigations upon a scale commensurate with the interests involved." See "Agricultural Experiment Stations," *Western Stock Journal and Farmer* 6 (1877), 246. On progressivism and populism in general, a bibliography would consume an entire volume. My own thoughts on the populism-progressive elision come from a critical reading of Hofstadter's *Age of Reform.* Thank you to Gregg Andrews for pointing out Elizabeth Sanders, *Roots of Reform: Farmers, Workers, and the American State, 1877-1917* (Chicago: University of Chicago, 1999).

persuaded some entomologists, farmers, and Americans in general to ultimately put their stock in insecticides as the best way to approach insect infestations.[6]

Even before they were systematically investigated, then, insecticides had the veneer of scientific legitimacy. But not all entomologists bought into it. The transition to widespread chemical insecticides would have been a much more mundane development in the history of agriculture had there not been a legitimate (and not mutually exclusive) alternative. But there was one, and it was not only viable, but it was one that America's first economic entomologists had originally accentuated and even celebrated with the utmost enthusiasm. It was also an alternative with a passionate spokesman.

Benjamin Walsh was a man who turned down divinity school, as he remembered it, to avoid being around hypocrites. He instead chose to run a 300-acre farm where he developed notions of biological control that he would later push as the solution to the nation's pest outbreaks. In so doing he managed, as Riley's iconoclastic co-editor of *The Practical Entomologist*, to offer a sharp counterpoint to nearly every reason for supporting insecticides. "Accident has furnished us with the bane," he explained in reference to the most destructive insect pests, and "science must furnish us with the remedy." Walsh's idea of science, though, was not insecticidal compounds; instead, it was something "as old as the hills," and something he practiced on his own farm for twelve years. Benjamin Walsh believed that the ultimate way to control pests was to do so with their natural enemies.

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[6] C. H. Tyler Townsend, "Insecticides and their Appliances," *Bulletin No. 9* [New Mexico College of Agriculture and Mechanic Arts, Agricultural Experiment Station] (Las Cruces: Rio Grande Republican, 1892), 10; the naturalistic/humanistic dichotomy is spelled out in John H. Perkins, *Insects, Experts, and the Insecticide Crisis* (New York: Plenum Press, 1982), 195.

The challenge, of course, was heightened by the fact that the injurious pests came from abroad while the enemies remained behind. "It is a remarkable fact," he wrote in 1866, "that fully one half of our worst Insect Foes are not native American citizens but have been introduced here from Europe." Because the United States "had only three or four parasites to check [their] increase," one "common sense remedy" was "to import the European parasites that in their own country prey upon the wheat midge, the Hessian fly, and the other imported insects that afflict the North American farmer." This solution was not only in keeping with the entomologists' own professional history, but it was also, he insisted, the safest and most reliable approach to the bug wars. Walsh developed a dedicated following, including the young Charles Riley, who was working as Missouri's chief entomologist when Walsh hired him to co-edit the *Practical Entomologist*. As farmers adopted insecticides at the end of the nineteenth century, they thus did so while a small but vocal group of entomologists, many of whom simultaneously supported insecticides, pushed biological control (and "clean farming") as a sensible competing (or even complementary) option to a singular reliance on chemical insecticides. There was, in short, a very real alternative. Walsh, Riley, and others were not shy about pushing it.

Retrospect is a privileged and prejudicial thing. We know the ultimate outcome of this battle: the United States became so thoroughly an insecticide nation that as early as 1892 a prominent entomologist could say of insecticides without the merest blush that "it is useless at the present day to question their efficacy."[7] Nevertheless, it is not useless/ to revisit this particular battle in real time, when the outcome was still unknown and the

[7] C. H. Tyler Townsend, "Insecticides and their Appliances," *Bulletin No. 9* [New Mexico College of Agriculture and Mechanic Arts, Agricultural Experiment Station] (Las Cruces: Rio Grande Republican, 1892), 4.

effectiveness of insecticides still in question. Of course, it is never encouraging to watch highly capable men make compromised decisions that would go on to produce widespread suffering and environmental degradation. But one can always hold out the hope that, in witnessing our forebears adopt the motto "let us spray," we might appreciate how Walsh's truncated alternative became more than a quiet historical footnote.

"a hodge-podge of ingredients such as enters the witches' caldron in Macbeth."

The destruction wreaked throughout the second half of the nineteenth century by chinch bugs, potato beetles, the San Jose scale, locusts, and Hessian flies drove desperate farmers to do something that their yeoman forebears never did: seek legislative help. "I think we should all strive to discourage this sentiment," wrote H. W. Wiley, "that politics is a dirty pool and that men of science should keep out of it." Not everyone, however, was so thrilled with the prospect of federal and local governments entering the bug wars. As he so often did, Walsh articulated his thoughts on the matter without pretense or politesse. "Probably about nine-tenths of the Members of Congress and of our different state legislatures are lawyers," he observed, "and the remaining one-tenth are physicians, merchants, and manufacturers." In case anyone missed the implication that legislators knew nothing about pest control, Walsh spelled it out: "Is it to be expected that a crowd of men, whose heads are mostly full of such important things as Cognovits and Assumpsits and Demurrers and Torts and Caucuses and Conventions should condescend to think about 'Bugs'?"

It was a good question. Farmers, especially small ones, would in fact be excluded from the "chaos of experimentation" as the bug wars became increasingly politicized.

With solutions being tested further away from the traditional crucible of the family farm, farmers became less relevant to the processes of bug control. Nevertheless, with the most powerful farmers and agricultural scientists clamoring for governmental intervention into the pest problem, and with pressure on legislators to apply (in true progressive fashion) the most cutting edge expertise and technology, the legislative turn became something of an inevitability (despite Walsh's assessment that "legislators are such very big bugs").[8] The consolidation of "the bug problem" onto a political stage thus placed the battle between chemical and biological solutions under a national spotlight. The farmers, as Walsh predicted, were removed from the theater.

However one felt about the legislative emphasis, its consequences were tangible. The most important piece of federal legislation to address insect infestations was the Hatch Act, passed in 1887. Adapted with overwhelming congressional support, it established and funded agricultural experiment stations in connection with state agricultural colleges founded under the Morrill Land Grant College Act (1862). The stated intention behind this measure was "to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science." The Hatch Act required experiment stations to explore such topics as "the physiology of plants and animals; the diseases to

[8] H. W. Wiley, "The Dignity of Chemistry," *Science* (13) 332 (May 10, 1901), 731; Benjamin Walsh, "Imported Insects," *The Practical Entomologist* (I) 12 (September 29, 1866), 119; Howard Seftel, "Government Regulations and the Rise of the California Fruit Industry: The Entrepreneurial Attack on Fruit Pests, 1880-1920," *The Business History Review* (59) 3 (Autumn 1985), 369; Charles E. Rosenberg, "Rationalization and Reality in the Shaping of American Agricultural Research, 1875-1914," *Social Studies of Science* (7) 4 (November 1977), 402; Richard A. Overfield, "Charles E. Bessey: The Impact of the 'New' Botany on American Agriculture, 1880-1910," *Technology and Culture* (16) 2 (April 1975), 162-163; Alan I. Marcus, *Agricultural Science and the Quest for Legitimacy: Farmers, Agricultural Colleges, and Experiment Stations, 1870-1890* (Ames: Iowa State University Press, 1985), xx.

which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth," in addition to manure, fertilizer, crop rotation, and cattle feed. In these respects, the act simply reiterated in national form what had been occurring on the state level since the early 1870s, when states started establishing experimental farms as venues for agricultural experimentation. In this sense it was unremarkable.

But the Hatch act did more than the letter of the law suggests. By adding an open-ended caveat to the many issues that experiment stations were supposed to investigate, it opened the doors to the Federally-funded research of insecticides. That caveat read: "and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable." Anyone reading between the lines of this legislative language—Howard and Riley, for sure—knew that the phrase was an indirect way of saying "see if these hyped-up chemical insecticides currently saturating the market have any value."[9] The Hatch Act directly touched on dozens of agricultural issues, but the one that was not specifically mentioned—insecticides—might very well have been the most critical. The Department of Agriculture needed a systematic way to see if the insecticidal concoctions flooding the agricultural market were valid. The Hatch Act was their chosen vehicle of investigation.

The agricultural scientists and entomologists who headed the newly established stations had their work cut out for them. The most common insecticides that farmers began to use in the 1870s were circulated by word of mouth, in newspaper reports, and in

[9] "Act of 1887 Establishing Agricultural Experiment Stations," copy of the legislation printed from (www.oardc.ohio-state.edu/www/hatch.html); for an institutional look at the rise of experiment stations and the Hatch Act see Alan I Marcus, *Agricultural Science and the Quest for Legitimacy* (Ames: Iowa State University Press, 1985), 59-61; 171-185.

agricultural magazines. If a farmer reported success, others jumped on the bandwagon and some variation of the "solution" spread. Unlike their twentieth-century counterparts, these insecticides derived from naturally occurring plants and minerals. Sometimes chemical companies synthesized and sold these washes and dusts; sometimes farmers bought the ingredients and manufactured the solutions themselves. Whatever the origin, and whatever the avenue of introduction, dozens of insecticides quickly entered the agricultural lexicon, and the first experiment stations were entrusted to evaluate them with disinterest and rigor.

A few insecticides already stood out for their popularity. Paris green—a bright green arsenite derived from copper dye and conventionally used as paint and wallpaper pigment—was being applied to kill insects as early as 1868 after a farmer painting his window shutters noticed the potato beetles in his tomato plants die after paint splattered the plants. Twenty-five years later Paris green was, according to the Mississippi Experiment Station, "probably more generally used than any other insecticide." London purple, also an arsenite (of lime) and also the by-product of a dye (analine), was another insecticide that began to make the agricultural rounds in 1878 after Hemingway and Co. of London sent three sample barrels of it to the Iowa Experiment Station, encouraging it to spray the solution on potato plants. It was soon being used much in the same way that Paris green was, although as a finer powder it suspended better in solution (but often burned foliage). Another popular chemical remedy was a kerosene emulsion. A pound of commercial soap and a pound of water heated to the boiling point, plus two gallons of pure kerosene oil (normally used as lamp fuel), yielded upon cooling a "gelatinous mass" that "at any time may be diluted in water to the desired strength and used." Carbolic acid emulsion came from adding “one part crude carbolic acid to from five to seven parts of [a] soap solution.” Other early manufactured insecticides included arsenite of lead, white arsenic, a lime/salt/suphur mixture, sulphate of copper and lime, and bisulfide of carbon.[10] As experiment stations turned their attention to these popular insecticides, the insecticides were already becoming part of a typical agricultural arsenal as fragmented reports of success cohered into a temporary consensus that they might very well be worth using.

So, before stations even began their investigations, the insecticides had something of a leg up. This advantage was intensified because Paris green, London purple, kerosene emulsions, and other chemical mixtures reflected a peripheral history of agricultural experimentation that encouraged farmers to explore a variety of creative options. Foremost among these options were natural insecticides. Pyrethrum, an insecticide made from a vegetable powder produced by grinding plant pedals of the pyrethrum genus and mixing the dust into ashes and water, had been used by farmers since at least 1807. Hellebore, an extraction from a species of herbaceous flowing plants, was another popular vegetable poison “diluted with five to ten parts of flour and dusted on plants through a muslin bag.” Tobacco was refined into “nicotine dust” and used routinely since the eighteenth century for its natural insecticidal qualities. Even common items such as soap, potash, tea leaves, sulphur powder, and whale oil served as insecticides well before the advent of economic entomology. Although more sophisticated in terms of production

[10] Hatch Experiment Station of the Massachusetts Agricultural College, *Bulletin No. 80: Fungicides, Insecticides, Spraying Calendar* (Amherst: Carpenter and Morehouse, March 1902), 9-12 (descriptions of how to mix several insecticides); Howard Evarts Weed, [Mississippi Agricultural and Mechanical Experiment Station], *Bulletin No. 27: Insecticides and their Application* Agricultural College, Miss., 1893), 2-4; F. H. Fowler, *Insecticides and their Application* (Boston: Wright and Potter, April 1891), 6-9; John H. Perkins, *Insects, Experts, and the Insecticide Crisis* (New York: Plenum Press, 1982),3-4; Adelynne Hiller Whitaker, “A History of Federal Pesticide Regulation in the United States to 1947,” 5.; E. O. Essig, *A History of Entomology* (New York, 1931), 423-431.

and application, the new arsencial sprays and kerosene emulsions that started to gain traction in the 1870s were the legitimate heirs of a familiar if distant tradition, and thus items that farmers and entomologists were inclined to accept before a series of governmental studies proved (or disproved) their worth.[11]

A second reason that the new insecticides struck an immediate chord of legitimacy was that, under highly controlled circumstances, they appeared to do something rather profound: they worked. An emerging faith in the effectiveness of insecticides started not with experiment station reports but, literally, at home. "Hot alum water," according to an 1870 New Hampshire newspaper article "will destroy red and black ants, cockroaches, spiders, chintz bugs, and all the crawling pests which infect our houses." *Farmer's Cabinet* promised in 1862 that "scattering chloride of lime" on wooden surfaces would eliminate "all kinds of flies." A Macon, Georgia newspaper, working from the assumption that "our houses and gardens are more or less infested," advocated in 1861 "a few drops of potent benzene," noting that "the bodies of insects killed by it become so rigid that their wings, legs, &c., will break rather than bend if touched." A Jackson, Mississippi publication pushed a "Persian insect powder" as a remedy against "most forms of insect life." Skeptics certainly frowned upon these reports of domestic eradication made by mere newspapermen, but they had a harder time dismissing the positive assessments of professional scientists. With the U. S. Commissioner of Agriculture reporting in1882 that Paris green "was successfully used for the control of the cotton worm," with a former California horticulture officer declaring in 1883 that London purple wiped out cutworms in California, and with a

[11] Esig, *History of Entomology*, 403-405, 438-450; E. G. Lodeman, *The Spraying of Plants* (New York, 1897), 5, 148; J. E. Dudley, "Nicotine Dust Kills Cucumber Beetles," *Bulletin 355* [Wisconsin Agriculture Station] (June , 1923), 1-10.

professor at Michigan Agriculture College reporting in 1877 that a carbolic acid-whale oil mixture eliminated orange tree scales, one could forgive farmers and their advocates for thinking that, with the onset of Paris green, kerosene, and London purple, they had discovered a cache of magic bullets.[12]

One danger, of course, was that many of these bullets could backfire. Legitimate insecticides competed with hundreds of quack remedies. Advertisements published in agricultural newspapers and bulletins disingenuously promised the world to ailing farmers in the form of elixirs and potions designed to kill any and all insects. "Hellbroths!," Walsh called them, while a contemporary scholar has gone on to deem them "worse than worthless." "The most absurd claims" proliferated, admitted Howard, based on the assumption that "farmers seemed to be especially easy to fool." Evidently some were. A California citrus grower doused his trees in a liquid compound he had purchased from the Ongerth Grafting Compound Company and watched his $17,000 citrus crop shrivel into charred brush over the course of a long, hot afternoon. A peach grower in Kentucky reported that his crop was ruined by a linseed oil product promoted as a weapon against the peach borer. Hapless farmers who took a chance on "Slug Shot," "Bug Death," Black Death," "Smith's Vermin Exterminator," or "Grape Dust," too frequently saw a year's work disintegrate. While many of these "insecticides" carried a patent, none were submitted for registration, a step that would have required the manufacturer to list ingredients. Revealing ingredients was exactly what a man like Benjamin Best, manufacturer of "Best Patent Fruit Tree and Vine Invigorator," aimed to

[12] "Giving Insects Fits," *New Hampshire Patriot* 3846 (February 25, 1874), 4; "Chloride of Lime as a Insecticide," *Farmer's Cabinet* (60) 50 (July 10, 1862), 4; "Abolition of Insect Pests," *Macon Daily Telegraph* 527 (December 7, 1861), 2; "Dalmation Insect Power," *The Clarion* (51) 27 (July 6, 1887), 1; Essig, *History of Entomology*, 406; U. S. Commissioner of Agriculture, *Report for 1881-1882*, 158-159; Matthew Cooke, *Injurious Insects of the Orchard, Vineyard, etc.* (Sacramento, California, 1883), 402, 420.

avoid. He could therefore promote his potion as “the most useful combination of ingredients ever offered to any people,” leaving his ornery counterpart, Walsh, to huff that it was actually “a hodge-podge of ingredients such as enters the witches’ caldron in Macbeth.” The farmer, caught in the rhetorical crossfire, often did not know his Shakespeare from rank hucksterism, and thus his crops suffered the consequences. In light of these scams, one of the many roles of the experiment stations was to separate the insecticidal wheat from the chaff.[13]

Among all these responsibilities, however, the most pressing matter that the stations had to contend with was the insecticides’ effectiveness. Would they work as a long-term solution to the bug wars? State agricultural stations and the U. S. Department of Agriculture might have been under political pressure to seek solutions to insect infestations, but, to their credit, their reports struggled honestly and patiently with questions of insecticide efficacy. Given the nation’s ultimate embrace of insecticides, however, what stands out so conspicuously throughout hundreds of investigations is the substantial amount of evidence found against the new insecticides. When it came to basic matters of safety, application, effectiveness, and practicality, the insecticides tested by experiment stations proved to be *problematic on every score*. This is not to suggest that the prevailing insecticides of the late-nineteenth century were entirely without merit. There is little doubt that pro-insecticide propaganda masked a kernel of truth, and that the insecticides occasionally saved many American farmers much heartache and numerous

[13] Adelynne Hiller Whitaker, “A History of Federal Pesticide Regulation,” 2-9; *Insect Life* II (Jan/Feb. 1890), 260; John H. Perkins, *Insects, Experts, and the Insecticide Crisis: The Quest for New Pest Management Strategies* (New York: Plenum Press, 1982), 4-5; John B. Smith, *Raupenlein and Dendrolene*, Division of Entomology Bulletin (USDA, 1895), 34; Benjamin Walsh, *Practical Entomologist* I (May 28, 1866), 74. For a list and evaluation of bogus elixirs see J. K. Haywood, “Insecticides and Fungicides,” *Farmers’ Bulletin No. 146* [U. S. Department of Agriculture] (Washington: Government Printing Office, 1902 (?), 10-13. Also see appendix.

foreclosures—at least for the time being. Under highly controlled circumstances, and measured by short-term objectives, petroleum and arsenic based insecticides certainly raised some optimistic eyebrows and inspired a few premature celebrations. But what the experiment station reports reveal more consistently than any other factor is that, for all their promise and supposed safety, the new insecticides were seriously flawed products. Their evidence deserves a closer look.

"A word of warning, however, may be in order . . ."

Although safety was not a pressing priority as entomologists undertook their investigations[14], it became a factor that they soon found hard to ignore. Enthusiastic as he was about the compounds he studied, entomologist C. H. Tyler Townsend had no choice but to admit the "supposed danger to man and animals from spraying with the arsenites." There was, he explained with some regret in 1892, "prejudice in the minds of some persons against the use of arsenicical sprays for injurious insects." His appeal to the contrary was somewhat compromised by his almost comical claim that "the only means by which fruits or vegetables of any kind can convey the poison to the consumer is

[14] In retrospect, it should have been. See http://yosemite.epa.gov; www.epa.gov; http://environmentalchemistry.com/yogi/hazmat/placards/class6.html; www.scorecard.org/chemical-profiles/summary; "Arsenic for Cotton Worms," *Fort Worth Gazette* (XV) 256 (June 28, 1891), 3; "Insects and Insecticides," *The Knoxville Journal* (X) 178 (August 22, 1894), 6; Contemporary studies have revealed chilling information that nineteenth-century farmers and insecticide pushers did not know. "Acute exposure to Paris green," according to the Environmental Protection Agency, "may require decontamination and life support for the victims." Less acute exposure, however, is no picnic. Signs of the slightest ingestion include "a sweetish metallic taste and garlic odor to breath and feces, difficulty in swallowing, vomiting, diarrhea, and dehydration." The U.S. Department of Transportation rates London purple a "division 6.1 poison," meaning that it is "presumed to be toxic to humans" and is "a material . . .which causes extreme irritation." Kerosene is a suspected endocrine toxicant, gastrointestinal intoxicant, neurotoxicant, and respiratory intoxicant. Lead arsenite is a proven carcinogen and reproductive intoxicant. Pyrethrum, although obtained from the innocent chrysanthemum, is a suspected carcinogen, immunotoxicant, and liver toxicant.

through the very small quantity of arsenic which may be left upon the outside of the edible portions of the plant."

This was cold comfort. A year earlier, the London paper *Pall Mall Gazette* had published a scathing report against American apples, calling them "unsafe on account of the large amount of arsenic which American orchardists spray upon their fruits." B. H. Fowler, a Massachusetts entomologist, pleaded with consumers to "keep all poisons out of reach of children and stock," and to "keep stock out of orchards for a few days after spraying." A report in the magazine *Insect Life* recounted how, as an investigator sprayed London purple onto "worm infested trees," a gust of wind "[made] the work exceedingly disagreeable, one of the men being made sick by having the poison blown in his face." A station report from Kentucky mentioned how "[t]he use of arsenical poisons in combating insects on cabbage . . .led to some misgivings regarding the possible dangers of this method to human beings" after several consumers claimed to have been poisoned after eating "dusted cabbages." In an 1898 experiment, after a "negro laborer" entered a room where livestock had been fumigated for lice, he "suddenly fell forward on his face unconscious." It took him five minutes to wake up. At the end of an endorsement for "bisulfide of carbon" as a powerful insecticide, a New Jersey entomologist noted, in a near parody of understatement, that "A word of warning, however, may be in order." The warning: "Bisulfide of carbon is poisonous. Its vapors kill animals and plants as well as insects. It is exceedingly flammable, and a spark is all that is necessary to cause a flash."[15]

[15] C. H. Tyler Townsend, "Insecticides and their Applications," 8-10; F. H. Fowler, *Insecticides and their Application* (Boston: Wright and Potter, 1891), 13, 15; *Insect Life* (IV) 5-6 (no date in my notes), 204-205; E. V. Wilcox, "Some Results of Experiment Station Work with Insecticides," reprint from *Annual Report of the Office of Experimental Stations for the Year Ended June 30, 1905*, 259; L. O. Howard, "The San Jose

By 1900 reports were attempting to control and quantify the potential risk. A bulletin put out by an Illinois horticultural organization noted that "it is well understood by orchardists that the deadly poisons here discussed must be used with a certain caution." Powders were to be thrown with the wind, it warned, and gloves were a necessity. Perhaps the authors had read the widely circulated bulletin from the Virginia Agriculture Station reporting how "the men found the wash [lime sulphur] quite unpleasant to their hands and very obnoxious to the face and eyes, and it became necessary for them to war gloves and cover their faces with veils." Drawing on experiment station investigations, the bulletin summarized "careful experiments with respect to the poisoning of pasture under the trees sprayed." The findings were not encouraging. Tests done on grass under sprayed trees found that it contained 20% of a poisonous dose of arsenic for a cow and 10% for that of a horse, figures that multiply exponentially when one considers, as the author did, that "arsenic is a cumulative poison, and a daily feeding for two or three weeks upon grass which had been sprayed with arsenites might have very different consequences than a meal or two." The bulletin then cut to the chase, admitting, "it may be well to note the poisonous nature of these substances for man." The sobering elaboration was that "[t]hey vary; for arsenic, from one-eighth to one-fourth of a grain for a two-year-old child, to one or two grains for an adult." The corresponding dosages for Paris green and London purple were "two or three

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Scale in 1896-1897," *Bulletin No. 12 –New Series* [U. S. Department of Agriculture—Division of Entomology] (Washington: Government Printing Office, 1898), 16-17; John B. Smith, *Cut-Worms: The Sinuate Pear Borer: The Potato Stalk Borer: Bisulfite of Carbon as an Insecticide* (New Jersey Agriculture Experiment Station, 1895), 36; when a San Marcos, Texas farmer discovered that "his plantation hands, all negroes" would have nothing to do with the arsenic he asked them to apply to his cotton crops ("not a mother's son would have anything to do with it"), "he hauled off his boots, placed half a pint of the poisonous solution into each, and then drew them on again." His insistence on arsenic's safety rested on the evidence that "no injurious effect whatsoever resulted." Too often, this kind of proof, buttressed by the claim of infallibility, sufficed.

times as much."[16] Whatever the amount, there was no denying the message that these substances were a threat to more than insects.

If safety concerns alone did not deter the popular acceptance of chemical insecticides, one might have expected the inherent challenges of insecticide application to have done so. Even if insecticides had been perfectly safe, they would still have been undermined by the near impossibility of mixing and spraying in uniform fashion—both of which were critical factors in effectively using insecticides. Kerosene emulsions, according to several experiment stations, led to "considerable difficulty" on account of the fact that "the mixtures are only of a temporary nature and not at all stable." Paris green, likewise, "sinks unless constantly stirred." The available equipment did not help, because "the various spraying machines which have been constructed for the specific purpose of making mechanical mixtures . . .have never been quite satisfactory." As emulsions quickly separated within spraying machines, the substance that doused the trees would either have so little oil that it was "of no insecticidal value" or it would have so much oil that it would "burn the foliage and otherwise endanger the plants." Stations routinely recommended that just enough oil be used "to moisten the surface of the leaves" without producing a "stream of oil which might collect in various places." Considering that this moisture had to land in the form of a fine mist and settle evenly on both sides of the leaves, farmers were quick to shrug off such requirements as an unnecessary bother. The Ohio Agriculture Station was theoretically correct in asserting that "the essential points to be regarded in the application of kerosene are the finest possible spray, the

[16] "Lime Sulphur Wash," *Bulletin of the Virginia Agricultural Station* 141 (October 1902), 235; s. a. Forbes, "Synopsis of Recent Work Done with Arsenical Insecticides," *Transactions of the Horticultural Society of Northern Illinois* (did not write down date/volume info), 318-319; to put the grain amounts in perspective, Townsend reported that insecticide runoff collected on a 72-foot patch of land around trees came to "four tenths of a grain of arsenic." See "Insecticides and their Appliances," 10.

completest and thinnest possible coating over the entire surface, and weather conditions favoring rapid evaporation." The trees also had to be dry prior to application.

As a practical matter, these points were essentially moot. No sprayer on the market could emit "an almost impalpable mist" (and if it could, the mist would dissipate in the slightest breeze). Beyond that problem, kerosene tended to sear leaves in the summer months (when the advised evaporation was more likely) and coating the underside of leaves was nearly impossible with a sprayer (which emitted a dense spray upwards). Plus, who could be sure that the weather would stay dry during the several days needed to spray so carefully and thoroughly? Many a farmer must have ridiculed the suggestion, made by a Professor Webster in Ohio, that kerosene would work best "if applied lightly with a brush."[17]

Preparing these solutions on their own—something farmers were strongly advised to do with so many bogus products infecting the market[18]—was often akin to following a painstaking cooking recipe. Consider C. H. Townsend's directions for making a "Winter Resin Wash" to use against the San Jose Scale. The listed ingredients included 30 lbs. of resin, 9 lbs. of caustic soda, 4.5 pints of fish oil, and 100 gallons of water. Townsend instructed:

Prepare by placing all the ingredients in a large boiler, and pouring over them about 20 gallons of water. Boil briskly for three hours, or until the compound is perfectly soluble in water. The boiler must now be slowly filled with hot water, care being taken to stir well, until it makes 50 gallons of hot solution. This should be strained through a fine wire sieve or a piece of fine muslin, when it can be diluted with an equal quantity of cold water, as needed for spraying.

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[17] E. V. Wilcox, "Some Results of Experiment Station Work with Insecticides," 250; this same report concluded that "it is not possible to kill all of the scales on infested trees for the reason that the spray does not come into contact with all of the insects"; C. H. Tyler Townsend, "Insecticides and their Applications," 5; L. O. Howard, "The San Jose Scale, 1896-1897," 20-21 (for the Webster remark).

[18] "It is better to mix for yourself an efficient insecticide, whose ingredients you know, than to use a manufactured one which is likely to prove useless." Quote is from C. H. Tyler Townsend, "Insecticides and their Applications," 4.

Not only was this procedure beyond the reach of the average farmer, but no matter how closely one followed directions, problems inevitably ensued. After sticking religiously to "the formula advocated by Professor Cook," Herbert Osborn reported in *Insect Life* that "the result was that we had what appeared to be an excellent emulsion." Osborn had mixed the kerosene solution in a glass jar, but his hopes shattered as he watched "the separation taking place, the white emulsified part rising to the top and the water or soapsuds gradually increasing at the bottom" and hardening into a useless "jelly." These failures of application lent credence to one entomologist's wry claim that "investigations are giving us improvement after improvement, some of which, unfortunately, are no improvement at all."[19]

Related to mixing and application problems were unwieldy external variables that farmers were asked to miraculously control if they sprayed with insecticides. Weather conditions, as already suggested, were critical. Kerosene might have required hot and dry weather, but "caustic soda" needed dampness. "If a solution of caustic soda alone is sprayed on the trees in dry weather," warned a New Mexico bulletin, "its causticity is lost and its action as an insecticide is at an end." But was this true for trees in New Mexico only? Few concrete answers were forthcoming. Some trees reacted adversely to some insecticides when their blossoms were still in bloom while vegetables avoided damage only if they were saturated at a very precise stage of growth. Was this true for every plant? Every insecticide? Nobody was saying. "All educated men," declared F. H. Fowler, "should pronounce vehemently and with one voice against spraying our fruit

[19] C. H. Tyler Townsend, "Insecticides and their Applications," 7-8; Herbert Osborn, "An Experiment with Kerosene Emulsions," *Insect Life* 4 (October 1891 to August 1892), 63; C. H. Fernald, "The Evolution of Economic Entomology," (noting further), 546.

trees with arsenites till the blossoms have all fallen.” But were it only so simple. The problem was that “less damage has been done by the arsenical insecticides when applied in May”—a month when flowers were in full bloom in most climates. Likewise, the May requirement butted against the advice that arsenic “should not be used on cabbage after the heads are two-thirds formed.” An Idaho entomologist insisted that “in all cases [in Idaho] the first application be made just after the petals fall and before the calyx closes.” Confusing matters further, spraying had to work around the schedule of bees, so as “to avoid poisoning [them] and other useful insects which visit the flowers.” If a farmer wanted to use hellebore he needed to know that the application should occur at night, that the hellebore had to be diluted with flour, and that the mixture had to be “dusted on plants through a muslin bag.” How he was supposed to see what he was doing, alas, went unmentioned.[20]

The maddening idiosyncrasies of mixing and applying insecticides might have been worth the trouble if insecticides had proven to be systematically effective. But, in the most startling finding of all, the results that late-century entomologists reported were mediocre at best. The most common negative charge to come from experiment stations and test farms was that the insecticides under review were useless. After assessing the impact of Paris green, London purple, and white arsenic on apple trees, a team of Vermont entomologists concluded that “[n]o benefit was derived from the application of the poison.” In another report kerosene was found to have “no insecticidal value.” New Jersey decided that an insecticide called salimene caused “no perceptible effect as the scale developed as freely on unsprayed trees.” The same bulletin called an arsenic-based

[20] C. H. Tyler Townsend, “Insecticides and Their Appliances,” 6-7; F. H. Fowler, “Insecticides and their Application,” 11; E. V. Wilcox, “Some Results of Experiment Station Work with Insecticides,” 262 (Idaho); F. H. Fowler, “Insecticides and their Application,” 11;

insecticide “absolutely ineffective” while dismissing the impact of lime and sulphur as “so small as to be hardly noticeable.” Sulfite of soda was deemed “ineffective,” potassium sulphide yielded results “not good enough to justify recommending the mixture,” and trees doused with caustic soda “were as bad as ever.” A California report concluded after a lengthy study of insecticides for scale insects that “it was better not to spray at all.” Pyrethrum had “no effect whatever” on plant lice, according to the USDA, while a dusting of pyrethrum on grub worms ended up producing a brood of “healthy pupae.” Other descriptions from other reports reveal such conclusions as “a perfect failure,” “nonsense,” and, last but not least, “worthless.”[21]

The discovery that an insecticide had no effect actually came as a relief to many researchers who knew that it was just as common for an insecticide to cause damage. “All the treated trees,” according to a New Jersey station’s evaluation of a lime-sulphur-salt mixture, “were as bad or worse than when the work was begun.” A California study revealed that “those orchards which had not been sprayed were found upon examination to be freer from scale than those which had been sprayed annually.” Crude oil and other “distillation products” produced oranges covered in strange white spots due to the fact that “the chief injury to vegetable tissue from oils was caused by a penetration of oils into the interior of the plants.” In Illinois researchers found that “London purple is certainly so caustic to the leaves [of peach trees] as to forbid its use under any circumstances.” An

[21] Prof. S. A. Forbes, “Synopsis of Recent Work with Aresnical Insecticides,” 319; E. V. Wilcox, “Some Results of Experiment Station Work with Insecticides,” 250; *Insect Life* (IV) 3-4 (November 1891), 154; John B. Smith, “Insecticide Experiments for 1904,” *Bulletin 178* [New Jersey Agriculture Experiment Stations], 3-5; F. W. Malley, “The Boll Worm of Cotton,” *Bulletin No. 24* [U. S. Department of Agriculture: Division of Entomology, 1891], 41-43; no author, “Reports of Observations and Experiments in the Practical Work of the Division,” *Bulletin No. 3* [U. S. Department of Agriculture: Division of Entomology, 1883], 20-23; “Dosing Trees with Sulphur and Other Substances,” *Insect Life* (I) 7 (January 1889), 223; “Alum as a Current Worm Remedy,” Ibid., 229-230; J. K. Haywood, “Insects and Fungicides,” 12.

apple tree treated with London purple was "very badly scorched." "Some injury was done to the tree," wrote a Missouri Station report, "when the carbon bisulfid was injected into the soil too close to the trunk" in a futile effort to kill wooly aphis. A peach sapling sprayed with crude petroleum in September was dead by the next July; the scientists "dug it out and found that [the death] had been from the root up." Apple trees in another experiment were "worse affected by the apple worm than the check trees not treated" while a test of London purple was "thoroughly unsatisfactory," with the mixtures "defoliating or at least badly damaging, the trees, and not protecting the fruit." White arsenic in solution "should undoubtedly be abandoned as dangerous, if not destructive, to foliage . . .if its application be followed by rain, it would probably even then take disastrous effect." On and on the reports went.[22]

None of these results should have been a surprise. A comprehensive 1886 report published by the USDA (a year before the Hatch Act was even passed) confirmed the ambiguous test results from dozens of insecticide investigations. Eighty-six experiments testing a variety of insecticides on a plentitude of pests did little to promote the benefits of insecticides. In only three experiments (copperas water on cabbage worms; soluble pinoleum on wooly aphids; and kerosene emulsion on caterpillars) were all the larvae killed. Aside from those, only 9 out of 86 experiments could be classified as successful (with over 50% of the bugs or larvae destroyed). Thus, fully 85% of the experiments were failures, both in terms of their being useless and/or causing damage. The remarks after each experiment summary, in many ways, said it all: "all worms have returned to

[22] John B. Smith, "Insecticide Experiments for 1904," 3-5; S. A. Forbes, "Synopsis of Recent Work with Arsenical Compounds," 315-317; John B. Smith, "Crude Petroleum as an Insecticide," *Bulletin No. 138*[New Jersey Agriculture Experiment Station, 1899], 5; E. V. Wilcox, "Some Results of Experiment Station Work with Insecticides," 250; *Insect Life* (IV) 3-4 (November 1891), 154

the leaves and are actively feeding" . . . "this injured both plants, one quite seriously" . . . "the larvae did not seem to suffer any inconvenience" . . . "cannot see that any were destroyed" . . . "three days later, the beetles had returned" . . . "the ants had returned to work in the old burrows" The USDA survey provided more than enough grist to question whether or not C. H. Fernald's 1896 labeling of the late nineteenth century as "the period of insecticides" was either false hope or shameless propaganda.[23]

A final factor pushing against the wholesale adaptation of insecticides was expense. The cost of purchasing ingredients to mix into insecticides, the time and labor required preparing them, and the need for extensive distribution equipment made the systematic use of insecticides something only the wealthiest farmers working the largest plantations could afford. Kerosene emulsion was one of the more promising of the available insecticides, but, as an Illinois entomologist admitted, "the amount required to saturate the earth will make this method of treatment far too expensive." A Kentucky state entomologist expressed a similar opinion about kerosene, explaining that when it came to the Hessian fly, "the cost of this treatment . . . was found to be greater than the extra yield of wheat thus obtained." (The report, echoing a more antiquated method, actually advised "simply picking the larvae up by hand.") Any farmer hoping to keep several basic insecticides in stock would have had to store large supplies of several potent chemicals. A recipe for "lime-sulphur-soda," for example, called for 30 pounds of lime, 15 pounds of sulphur, 6 pounds of caustic soda, and 50 gallons of water. One pound of Paris green needed 50 pounds of flour to be mixed with it. Arsenate of lead required 4 ounces of arsenate of soda, 11 ounces of lead, and a whopping 150 gallons of water.

[23] F. M. Webster, "Reports of Experiments with Various Insecticide Substances," *Bulletin No. 11* [US Department of Agriculture: Division of Entomology, 1886], 9-22; C. H. Fernald, "The Association of Economic Entomologists—Address by the President . . ." *Science* (IV) 94 (October 16, 1896), 544.

But it was equipment that was the real drag on farmer finances. Distribution of powdered insecticides demanded costly duster guns and bellows, while liquid insecticides called for “knapsack” pumps, tubes, spray nozzles, a variety of attachments and extenders, as well as mechanical mixers. John B. Smith echoed a common complaint when he wrote that “the larger pumps, for orchard work, are altogether unreliable.” Every part of a pump and its components had to be kept well-oiled and clean, the pistons had to be kept free of even the finest debris, and the nozzle unclogged and cleaned after every use. Matters were made even more complicated and costly by the fact that many nozzles and spray guns were designed to disperse specific insecticides, thus requiring the farmer to own several variations.[24] In this way, insecticides—with their high cost and singular emphasis on a single pest and single crop—helped further the cycle of monoculture that had gotten the farmers into their bind in the first place.

“ . . . and I would like to know its enemy . .”

As negative as the evidence was, insecticides nevertheless enjoyed the political and scientific spotlight as viable remedies to late-nineteenth-century insect outbreaks. But they were not alone. While entomologists like Howard were testing and touting insecticidal solutions, other entomologists and agricultural scientists continued to explore biological control. In addition to having a longer history on its side, biological control was riding the wave of a recent and well-publicized victory. In 1886 an insect called the cottony-cushion scale, which had been imported accidentally from Australia, proliferated to the point of undermining the California citrus industry. At the behest of Riley, by then the U. S. Entomologist, the USDA sent Albert Koebele, an insect enthusiast, to Australia

[24] Where did this note go? John B. Smith, “Crude Petroleum as an Insecticide,” 22.

in 1888 to research the cottony-cushion scale's natural predators. Koebele quickly discovered a ladybird beetle, known as a Vedalia beetle, which proved capable of consuming the scale with impressive voracity. In January of 1889 he sent three boxes holding a total of 129 beetles to California, where state entomologists bred them for experimentation in local citrus fields. By June 1889, entomologists were able to turn loose 10,555 Vedalia beetles. In so doing they also turned the scale from a destructive insect into one that "ceased to be a major pest." The results were indeed spectacular. Shipments of oranges from California tripled by 1890. "We fully expect," editorialized *Insect Life*, "to learn of the increase and rapid spread of this new introduction, as well as of the other predaceous species which have been introduced." The Vedalia story, according to E. O. Essig, an early twentieth century entomologist, "furnished to the world the first demonstration of effective natural control." Even the *New York Times* weighed in, labeling the Vedalia "a complete success."[25]

The celebratory rhetoric lauding the defeat of the cottony-cushion scale was sweet vindication for Benjamin Walsh. Writing vigorously in *The Practical Entomologist* back in the 1860s, he had espoused biological control with characteristic passion. As Walsh saw it, the United States was choked with flora from the old world, and those crops were too often exposed to both indigenous and foreign insects whose ecological history did not mesh with that particular cash crop. A common result, of course, was complete and utter devastation. A case Walsh liked to highlight was one involving sawflies:

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[25] V. G. Dethier, *Man's Plague?*, 144-145; E. O. Essig, *A History of Entomology* (New York: MacMillan, 1931), 125; Albert Koebele, "Report of a Trip to Australia . . .to Investigate the Natural Enemies of the Fluted Scale," *Bulletin No. 21* [U. S. Department of Agriculture: Division of Entomology] (Washington: Government Printing Office, 1890), 6. *Insect Life* quotation is from Koeble's report; "How Hawaii Got Rid of Insects," *New York Times* (August 8, 1897), 18.

On the one hand, then, we find a native-born American Sawfly, feeding on currant and gooseberry bushes, which has existed in the United States ever since the country was first settled up by the white man, yet was never noticed by anyone, so far as I can find out, as a noxious insect till the year 1865, and then merely in a few scattered locations. On the other hand we have a European Sawfly, feeding on gooseberry and currant bushes, which has only been introduced into the United States five or six years [ago],and then merely in small numbers, and yet has already almost put a stop to the cultivation of these plants .

The implication could not have been more basic for the sober minded Walsh: “if we wish to fight effectually against those noxious insects which have been introduced among us from Europe, we must fight them by the instrumentality of the strong and energetic foes that make war upon them in their own country.” Not only was this natural approach to the bug wars replete with “common sense” and “comparative cheapness,” but to do otherwise, Walsh concluded, was like “sending out a fleet of old fashioned wooden ships to oppose a fleet of ironclads.”[26]

Other entomologists who believed in fighting iron with iron spoke approvingly of biological control. “The subject of parasitism is of intense interest,” Charles Riley told the Entomological Society of Washington in 1893, and there was ample evidence to buttress his assessment. Two years earlier F. M. Webster, the Ohio state entomologist, reported in a study of the Hessian fly that “it is proper to say here that the pest suffers much from the attacks of several minute parasites, which attack and destroy it in both the egg and larval or maggot stage.” A USDA survey that same year noted that “the boll worm was scarce during the past season.” The surmised reason was, barring the possible

[26] Benjamin D. Walsh, “Imported Insects; the Gooseberry Sawfly,” *The Practical Entomologist*, 119-124; Walsh was unfortunately fond of making his biological points with racially vulgar analogies. For example, another way he made the wooden ship/ironclad point was by saying, “it was as if Louis Napoleon were to land an army of a hundred thousand Frenchmen of the highly improved Caucasian race, in the United States, and we had nothing to oppose to that army but a crown of red Indians of the old fashioned indigenous North American type.” Ibid., 119. For a twentieth-century analysis of the influence of race on insecticide use, see Edmund P. Russell, “’Speaking of Annihilation’: Mobilizing for War Against Human and Insect Enemies, 1914-1945,” *Journal of American History* (82) 4 (March 1996), 1505-1529.

ravages of a “butcher bird,” “a common species of Soldier bug [that] was found devouring a large full-grown boll worm.” The pupa of this Soldier bug [*Podisus Spinosus*] was observed to “puncture the eggs and suck their contents.” A test pupa placed “on a branch of cotton with some newly hatched boll worms” proved that the worms indeed had fallen “victim to its beak.” Before Koebele decisively solved the cottony-cushion scale problem, other entomologists in California were reporting that “the larva of a little moth . . .is also known to feed on the eggs.” They also remarked that “the most important of its insect enemies are a species of earwig not yet identified, and a number of mites not yet carefully studied.” Others were encouraged by a scale-eating chalcid-fly, explaining, “the probability is that this little friend was introduced from Australia with its host.” The state entomologist of Illinois became so intrigued with a bacterial disease attacking the corn worm that he saved “several successful cultures in solid and fluid media [as] ample material for the study of this Bacillus.”[27] These were all promising leads into the bug wars and, like a bunch of scintillating rumors, they made the rounds through the entomological community with a certain amount of quiet intensity.

Sometimes rumors morphed into sustained interest, followed by a formal investigation or two. “There is no question,” wrote a USDA bulletin, “but that it is very desirable to introduce . . .enemies and parasites as can be introduced.” Riley occasionally stepped beyond his enthusiastic rhetoric and took action. Reports of a

[27] C. V. Riley, “Annual Address of the President,” *Proceedings of the Entomological Society of Washington* (II) 4 (Washington, DC, no publisher given, 1893), 2; F. B. Webster, “The Hessian Fly,” *Bulletin of the Ohio Agricultural Experiment Station* (IV) 7 (November, 1891), 133; F. W. Malley, “The Boll Worm of Cotton,” *Bulletin No. 24* [U. S. Dept. of Agriculture: Division of Entomology] (Washington, D.C.: Government Printing Office, 1891), 27; C. V. Riley, “The Icerya or Fluted Scale,” *Bulletin No. 15* [U. S. Department of Agriculture: Division of Entomology] (Washington, DC: Government Printing Office, 1887), 13; S. A. Forbes, “On a Bacterial Disease of the Larger Corn Root Worn,” *Seventeenth Report of the State Entomologist on the Noxious and Beneficial Insects* (Springfield, Ill: Rokker State Printer and Binder, 1891), 72-73.

Hessian fly parasite inspired him in 1890 to import "from England a foreign species of these parasites, some of which have, by his instruction, been turned loose in the fields in the vicinity of Columbus [Ohio]." A 1901 publication on wheat insects spilled considerable ink on biological control, noting for example how the Hessian fly was subject to many predators back in Europe" which were "effective . . in limiting damage." Of the wheat plant louse the same bulletin noted that "fortunately this species has many natural enemies, including various insect-feeding beetles and flies and also true internal parasites." An 1894 update on the boll worm placed "special stress and importance" on "the egg parasite," reiterating that "its value cannot be overstated." Studies of ants, moreover, "make it absolutely certain that at that season they frequently capture a boll worm." A "small Capsid found abundantly on corn silks" was promised to be treated more thoroughly in a future report (but, typically, never was). All in all, the attention that entomologists were paying to biological control was proof that Riley and Walsh, by favoring traditionalism and gradualism, had preserved more than a handful of dedicated followers.[28]

What wider public support these men garnered is hard to say. But every now and then hopeful information on parasitism and biological control eked its way into the popular press. In 1888 the *San Jose Mercury News* reprinted a speech delivered by the New York state entomologist, J. A. Lintner, to the American Pomological Society. "The introduction of foreign species without their natural enemies," he explained, "was another source of danger and loss to the horticulturist." He pleaded for a program to oversee

[28] "The Icerya or Fluted Scale," 25; F. M. Webster, "The Hessian Fly," 136; C. L. Marlatt, "The Principal Insect Enemies of Growing Wheat," *Bulletin No. 132* [U. S. Dept. of Agriculture] (Washington, DC: Government Printing Office, 1901), 19, 24; C. V. Riley, "Reports of Observations and Experiments in the Practical Work of the Division," *Bulletin No. 26* [U.S. Dept. of Agriculture: Division of Entomology, 1891), 48.

biological control because “sometimes years elapsed before chance brought the natural enemies.” A *Dallas Morning News* feature on failed attempts to control the gypsy moth (accidentally introduced in 1889), recounted how “the thick underbrush of an infested forest was sprayed with Paris green” and “cocoons were collected and placed in barrels covered over with gauze.” The point of this procedure “was to prevent the escape of the gypsy moths,” but the writer could not muffle his anger over the fact that “the parasites that prey upon them were permitted to get away.”[29]

What was ultimately missing among these positive reports and references to biological control was a concentrated focus, an effort to consolidate information, and sustained governmental backing. In 1878, Samuel Scudder, president of the Cambridge Entomological Club, joined Walsh in declaring his preference for biological control. “Histories of insects,” he wrote, “furnish the fundamental data upon which will be based much of the future of entomological science.” He rallied entomologists to trumpet “the biological results of the investigations of injurious insects.” At the same time he lamented that hundreds of “octavo pages” on parasitism were currently scattered across random locations or, in many cases, unknown. The problem was one of exposure and organization more than potential or effectiveness. Many biological control reports might have enjoyed a blurb or two of attention in the occasional USDA report or newspaper column, but who really knew, for example, that an Ohio entomologist had found that lady beetles destroyed chinch bugs? Or that the common quail ate them with gusto? Who knew that a fungus was ably wiping out the San Jose scale in parts of California in the late 1890s? Or that limneria “gives promise of being a very efficient aid in keeping [the

[29] “Insect Pests, a Noted Entomologist Expresses Some Opinions,” *San Jose Mercury News* (XI) 148 (January 14, 1888), 3; “Fighting an Insect,” *Dallas Morning News* 19 (January 6, 1895), 19.

red humped caterpillar] in check"? Who knew that "a species of Apanteles infests the Gypsy Moth in Japan"? Who knew, in short, the answer to one *Insect Life* reader's pressing question about the dead grubs scattered throughout his yard: "I would like to know its enemy"?[30]

In the past, it had been the farmers who knew the answers to these questions. And it is on this point where the near singular emphasis on insecticide research in the late-nineteenth century, as well as the naïve optimism that insecticides would become a sure fire solution, comes into sharper focus. Farmers were no longer directly involved in deciding how the bug wars were fought. As they expanded their farms, and as insect infestations became more damaging as a result, they gradually became dependent on (and demanding of) outside experts for answers to increasingly intractable problems. To be sure, many of these "experts" were interested in nothing more than making a buck off another man's misery. But other agents in the modernizing bug wars—Howard among them—were sincerely hoping to ease the plight of American agriculture with the most sophisticated solutions available, or at least foster some meaningful short term results. Federal and local governments, state and university entomologists, agricultural scientists, chemists, and chemical corporations fought their battles in the lab, at state experiment stations, and at annual meetings of scientific associations. Farmers waited for the outcome—one that would be endorsed by the government, the scientific establishment, and commercial interests—and generally did not contest the widely reiterated advice that

[30] S. H. Scudder, "Recent Progress of Entomology in North America," *Pysch: Organ of the Cambridge Entomological Club* (II) 45-46 (Jan/Feb, 1978), p. ?; no author listed, "The Chinch Bug," *Bulletin 69* [Ohio Agriculture Experiment Station] (Columbus, Ohio: State Printer, 1896), 72-73; L. O. Howard, "The San Jose Scale in 1896-1897," 6. no auth. "The Red Humped Caterpillar Killed by Parasites," *Insect Life* (IV) 5-6, 207; "Japanese Parasite of the Gypsy Moth," *Insect Life* (IV) 5-6 (December 1891), 227.

told them to spray. Their own fund of knowledge, after all, was becoming obsolete, and the new insecticides, despite the evidence, came with grand promises.

What about Walsh, Koebele, and Riley? Entomologists who continued to push methods which were more consistent with decentralized strategies of pest control wedded to the insights of common farmers still had an argument to make. What these men had shown was that when the government and the entomological community (both led by Riley) backed local efforts to find biological solutions to insect infestations, results could be rapid and spectacularly successful. But Koebele and the cottony-cushion scale turned out not to be a promising continuation of a more traditional agricultural history, but rather an exception that proved the rule. Despite E. O. Essig's assessment that biological control "has almost always brought either complete or partial subjugation of the pests," the encouraging leads documented in the obligatory "natural enemies" paragraph in almost every agricultural station report published were never systematically followed. Instead, they suffered neglect under the smothering weight of chemical insecticides. Fifty years after Howard and Riley drank their beers in Washington, Howard was the one left standing.[31]

. . . "what is a farmer to do?"

Status, pressure from farmers for a quick fix, political expediency, a quest for power—all of these factors partially explain the widespread adaptation of a "let us spray" philosophy. If there was, however, an ultimate and underlying reason behind the chemical transition that would come to shape the twentieth century, and if there was an ultimate and underlying reason that biological control never benefited from sustained

[31] Essig, *History of Entomology*, 125.

investigation, it was likely this: biological control was inconsistent with the commercialization of American agriculture. Wheat, corn, fruits, vegetables, and everything else that came from an American farm in the nineteenth century was, after centuries of agricultural development, part of an ecosystem in theory only. More realistically, these products had become national and international commodities in a market; they had become "outputs" in a system of expansive commercial agriculture that found the idea of biological control quaint. Insecticides and the equipment required to use them were certainly expensive, much more expensive than importing some bugs and rotating some crops, but they were the favored choice because they allowed American farmers to continue to make the same agricultural mistakes they had been making for centuries. They allowed, and maybe even *encouraged*, farmers to expand indiscriminately, ignore the barriers presented by natural conditions, plant monoculturally, and move elsewhere when the land fell into exhaustion. Recipes, sprays, and expense notwithstanding, insecticides did not demand a fundamental alteration in agricultural behavior. In this critical respect, they were the easy way out.

Biological control, by contrast, worked from the premise that a change had to occur. It assumed what agricultural writers Will Tracy and George Parmelet put into words: "keeping down insects means work." It was the kind of work, moreover, that asked farmers to think in an entirely more holistic way about agriculture. The gist of the matter was that "injuries may be prevented by a *better system of agriculture,*" and it assumed that complete extermination was not only impossible but undesirable. The elements of this system can be glimpsed in a variety of remarks. L. O. Howard, writing before he became a staunch insecticidal advocate, went so far as to promote "diversified farming with wheat left out" as an antidote to the chinch bug infestations. Cultivation of staple crops had to be moderated by a well-balanced spread of crops because, as a member of the Entomological Society of Washington explained, "[a]lmost every year some species scarcely heard of before thus becomes conspicuous." Biological control advocates knew that farmers were fostering the beasts that plagued them, and that, no matter how powerful the chemical dosage, no matter how devastating its immediate blast, they were going to keep creating those beasts until they reformed their methods of farming. "Prevention is always better than cure," wrote John Smith, "and very frequently serious injury may be averted by doing ordinary farm work at just the right time, or in exercising care in the selection of fertilizers or in the rotation of crops." His advice included having chickens follow the plough, allowing turkeys to control for grasshoppers, using salt fertilizer instead of animal manure, paying careful attention to "the selection of the time of planting," planting an early "trap crop of mustard," and keeping cranberry bogs under water until May, "thus compelling the moths to lay their eggs on other plants belonging to the same natural family." Rarely articulated, the point was nonetheless clearly implied that biological control had to operate in the context of these more traditional measures—ones that were undertaken on smaller, more diversified, and better managed farms—if it was to have a sustained and sustainable impact on the insect population.[32]

Biological control, in other words, was about more than just biological control. It was also an important piece in the larger puzzle of what progressive agricultural scientists

[32] Will W. Tracy and Geo. Parmeler, "Report: Injurious Insects and the Means of Exterminating Them, (1875), 4 (need more info on this source); John B. Smith, *Economic Entomology for the Farmer and Fruit Grower* (Philadelphia: J. B. Lippencott, date?), 423-427; "Annual Address of the President," *Proceedings of the Entomological Society of Washington* (1) 1 (March 12, 1885), 18.

were starting to call “clean farming.” (Today we would call it “integrated pest management”). This approach to farming did not have a founding manifesto, but its many advocates spelled out their ideas in piecemeal fashion through a variety of popular publications. Riley’s early report on the boll weevil remarked that “all insecticidal measures of any nature [are of] little or no practical value.” “An improved method or practice of farming,” he explained, “not the spraying of insecticides,” was the proper answer. F. W. Malley advised arranging the cotton field so that “four or five rows of corn are planted for every forty or fifty rows of cotton.” The extra prudent farmer should also plant “peas [when] the crop is in the height of its blooming period.” An entomologist at the Ohio Agricultural Station advised “sowing at the proper time; rotation of crops; [and] sowing long narrow plats in the summer as baits” as solutions to combat the Hessian fly, adding that “none of the measures are original with me, and in fact the most of them are as old as the history of the [human] species itself.” One farmer reported how “the striped bugs had nearly destroyed our cucumber vines last season.” His solution was “to set three or four [tomato plants] in each hill of cucumber vines,” and, to his delight, “the bugs left and the vines grew luxuriously” on account of “the odor from the tomatoes.” To prevent soil exhaustion, a “Farmer’s Department” column in a local paper promoted “a good mixture of seed . . .two bushels of orchard grass, two bushels of blue grass, two bushels of redtop, and one bushel of fescue,” adding that “the loss of fertility in the soil depends entirely upon the kind of crop growing therein.” A “Facts for the Farmers” article reminded farmers who were cultivating acres upon acres of cotton that “variety conduces to health” and that “too much should not be expected from any branch of industry.” Diversified crops and grasses, according to another agricultural report, encouraged a diversity of wildlife, including “toads, lizards, birds, and fowls,” all of which “destroy millions of insects.” The upshot: “encourage them.”[33]

There is, finally, another way to think about the relationship between insecticidal and biological control. Insecticides were the wave of the future while biological control and the reforms it required asked farmers to stick with the past. When entomologists instructed early twentieth-century farmers to plant patches of corn “to lure the cotton boll worm,” to use radishes “as a trap crop for the root maggots,” and plow in late fall to destroy hibernating insects, they were evoking what to many progressive farmers had come to seem antiquated and even a little naïve. They were, in essence, tapping into a time long gone, a time when common farmers were writing to agriculture magazines in an effort to cooperatively hammer out solutions to an age old agricultural problem. It was “back then,” in the 1830s, 40s, 50s, and even in the eighteenth century, when farmers were advising that, as a “Genesee farmer” did, “A farmer should never undertake to cultivate more land than he can do thoroughly.” It was a time when the most astute reformers noted that “an overweening desire to accumulate too fast” had “desolated many a farm house.” It was a time when the yeoman farmer, however mythical he may have been, still captured the imagination and validated the claim, made in an 1830 issue of *Farmers’ Cabinet*, that “a farmer should shun the doors of a bank as he would an approach of the plague.” It was a time when the farmer should, the powers that be

[33] C. B. Simpson, “Report on the Coddling Moth Investigations in the Northwest During 1901,” *Bulletin No. 35* [US Department of Agriculture: Division of Entomology] (Washington: Government Printing Office, 1902), 20, 25-28; F. W. Malley, “Report of Progress in the Investigation of the Cotton Boll Weevil,” *Bulletin No. 26* {USDA: Division of Entomology] (Washington, DC: Government Printing Office, 1892), 48-52; F. M. Webster, “The Hessian Fly,” 281; “Our Farmer’s Column (Selected Items from the Best Agricultural Journals),” *Clarion Ledger* (52)20 (June 21, 1888) 1-3; “Facts for the Farmers,” *Macon Weekly Telegraph* 51 (November 11, 1885), 10; “About Experiments,” *Dallas Morning News* (April 26, 1896), 18.

advised, stay small, diversified, and—as he forbears would have so well appreciated—in control.[34]

Benjamin Walsh and Charles V. Riley would certainly have shared the sentiment about avoiding the plague, as well as the advice that farmers remain in control. As it turns out, though, they were both taken down by other forces beyond their control. On November 12, 1869, Walsh was hit by a train while reading his mail as he absentmindedly walked home from the post office. Sixteen years later, on September 14, 1895, Riley—who started the *American Entomologist* with Walsh and went to the mat with Howard over insecticides—broke his skull on the pavement and died after a fall from his bicycle. History is full of symbolic twists and turns, and one should not make too much of their intriguing coincidence, but it seems appropriate enough to note that, with the premature deaths of these entomological pioneers, biological control also died a similarly premature death as a popular method of pest control. By 1900, as the swell of insecticides reached an imposing peak, Walsh and Riley were safely interred in their graves, protected from the crash that would submerge the twentieth century in a flood of insecticides far more dangerous than they could have ever imagined.

[34] E. Dwight Sanderson, *Insect Pests of Farm, Garden, and Orchard* (New York: John Wiley & Sons, 1921), 35-37; Genesee Farmer, "Things a Farmer Should Not Do," *Farmers' Cabinet* (1) 1 (July 1830), 13; no author, "Farm Economy," *New England Farmer* (XVI) 6 (June 1864), 183.