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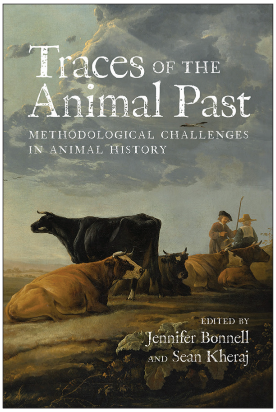

TRACES OF THE ANIMAL PAST: METHODOLOGICAL CHALLENGES IN ANIMAL HISTORY

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ISBN 978-1-77385-385-7

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Occupational Hazards: Honeybee Labour as an Interpretive Device in Animal History[1]

Jennifer Bonnell

In an influential 2003 article in *Labor History*, Jason Hribal argued that "animals are part of the working class." Like human labourers, horses, oxen, mules, and other working animals came to form a kind of proletariat in the context of industrializing nineteenth-century cities and farms. They registered instances of resistance, including violent outbursts and refusals to work, which prompted varying forms of negotiation by their human employers. Recognition of the interconnected exploitation of animals and workers, Hribal argues, led nineteenth-century reform organizations to initiate linked movements for worker and animal rights. Human and animal workers, he concludes, shared a "mutual struggle" against exploitation in industrializing economies.[2]

Questions of animal agency, however, have limited usefulness in interpreting historical records.[3] The extent to which working animals resisted their plight can tell us only so much. Ultimately, those instances of animal agency that we can interpret from our sources reinforce what we already know to be true: animals were, and are, sentient creatures with motivations of their own and forms of intelligence that, collectively, we have been unable or unwilling to comprehend.[4] As Joanna Dean and Jason Colby demonstrate in this volume, we might better comprehend the historical lives of animals by considering the work they performed—either for their human keepers or for reasons of their own—and the changing circumstances within which they worked.

This chapter modifies Hribal's challenge to consider animals—in this case, honeybees—not as a proletariat that resisted their oppression, but rather as workers whose changing work environments had repercussions for their health and the viability of their keepers' operations. If, in taking up Hribal's logic, we regard honeybees as workers (the familiar classification of the adult female majority as "worker bees" simplifies this leap), we can extend this logic to consider the environments they labour within as places of work with better or worse working conditions. To be clear, following Donna Haraway and Edmund Russell, I consider honeybees to be neither human slaves nor wage labourers but rather animal labourers "who produce surplus value by giving more than they get in a market-driven economic system." Beekeepers "enlist their cooperation" in the productive and reproductive jobs they perform in service of the colony as a superorganism. Bees work, in other words, but they do not (at least purposefully) work for us.[5] Regarding honeybees as animal workers allows historians to take their labour, and the changing conditions within which they worked, seriously. We can consider the risks and opportunities presented by a given environment from the perspective of the worker (the bee) and the beneficiary of that work (the beekeeper). Further, we can attend to the ways in which beekeepers responded to the experience of their bees and sought to direct, maximize, and protect their productivity.

Conceiving of animals like honeybees as "workers" rather than as "resources" has implications for our understanding of political economy more broadly, displacing an anthropocentric assessment of usefulness with a recognition of the ecological relationships that exist regardless of our presence.[6] Animals, from this perspective, are transformers of non-human nature in their own right: through their labour, honeybees transform nectar into honey, just as barn swallows transform mud pellets into cup-shaped nests and bison turn grass into insect-sustaining dung. Appreciating the intersecting roles of humans in this process, as beneficiaries and enablers, casualties and disruptors, is one of the central projects of environmental history.

Certainly, a large literature exists on the history of animal labour. While much of the scholarship on occupational hazards has focused on human work environments, historians of labouring animals have taken an ecological approach to examine the role of changing environments on labouring animal bodies. Clay McShane and Joel Tarr's classic study of working horses in nineteenth-century American cities, for example, explores the problem of limited access to drinking water on city streets and the hazards of fire and disease exposure in crowded city stables (on the latter, see Kheraj in this volume).[7] Explorations of animal labour and working conditions, however, have largely been confined to animals traditionally conceived of as "labourers": horses, mules, donkeys, oxen, and elephants. A more expansive view of human-animal working relationships—and the ways humans have profited from animals that labour *for themselves* and for their own societies—has featured in more recent scholarship.[8]

Scholarship that has taken up the topic of labour as a combination of human and non-human forces offers some useful direction. Among environmental histories, Richard White's *Organic Machine* was one of the first to examine the ways that human labour and engineering intersected with the non-human entity of the Columbia River in the production of work.[9] More recently, Thomas G. Andrews' *Killing for Coal* presents the concept of "workscapes," "places shaped by the interplay of human labor and natural processes." By conceiving of work as a "constellation of unruly and ever-unfolding relationships" between land, air, water, bodies, and organisms, Andrews suggests historians can treat people and, in this case, animals as "laboring beings who have changed and been changed in turn by a natural world that remains always under construction."[10] The relationality between humans, other animal species, and non-human entities, such as rivers, tides, and coal seams, in this conception of work offers space for thinking about the ways all participants are transformed in the process.

Beekeepers, like hydro-electric engineers and coal company managers, operated within complex and changing workscapes that blended human and animal labour with the work of natural processes. In my larger study of beekeeping and environmental change in the Great Lakes region in the late nineteenth and early twentieth centuries, I have reviewed decades of detailed beekeeper association records, such as those of the Ontario Beekeeping Association, published annually since 1881, and bee-keeping periodicals, such as the weekly *American Bee Journal* (distributed in the United States and in Canada). These records document beekeeper concerns as managers of honeybee labour and work environments. And they place into relief the considerable limits in control that beekeepers exercised over the semi-domesticated foraging insects that they kept.

Fundamentally, the work that honeybees do (and which their human keepers benefit from) involves gathering pollen and nectar from flowering trees and plants and transforming these floral essences into products (most notably honey) for human consumption. Beekeepers, in return, provide a suitable structure where honeybee colonies can live and work, where they can access floral landscapes and sources of water, and where they can have limited protection from other, non-human predators (such as bears, badgers, and predatory insects). In addition, beekeepers assist in maintaining the sanitary condition of the hive (honeybees do the bulk of this work themselves), and they monitor the health of their worker colonies. In this way, honeybees and beekeepers are, in Haraway's words, "mutually adapted partners" in the work of production and reproduction.[11]

Beekeeper management, however, is challenged by the unusual degree of liberty enjoyed by their workers. Honeybees, unlike most forms of livestock, cannot be fenced in. Neither fully domesticated nor fully wild, they possess a freedom to forage. Honeybees are not alone in occupying this liminal status between wild and domesticated: historically and in limited instances into the present, they have shared this status with other animals, such as cattle in the pre-barbed-wire American and Canadian West, reindeer herds in the Global North, and the feral horses that Swart explores in Chapter 1.[12] In each case, forage freedoms have been accompanied by varying burdens of risk for human keepers. What honeybees find, and fail to find, on their foraging flights has long been a source of concern for beekeepers. The costs of this freedom range from unpalatable honey due to unintended forage sources, exposure to parasites and infectious disease, and losses resulting from insecticide poisoning. This fundamental inability of beekeepers to control the movement of their bees led them to direct their energies instead to mitigating the risks presented by their working environments.

Working conditions for honeybees, furthermore, did not remain static over my period of study. My sources document a shift from the relatively untroubled years of beekeeping in the Great Lakes region in the mid-nineteenth century to the novel concerns that emerged in the 1880s and 1890s. As agriculturalists adopted increasingly industrial forms of production in this period, honeybees and their keepers became the unintended targets of responses to insect outbreaks and reductions in wildflowers and other forms of "bee forage." Honeybees also became subject to disease risks and pests of their own. As working animals within industrializing agricultural landscapes, honeybees not only suffered the consequences of industrial-scale food production (through disease, parasites, and insecticide poisoning), but also took on industrial functions themselves in this period as pollinators of expanding and increasingly monoculture orchard crops.[13] The records I examine describe the onset of these changes in the late nineteenth and early twentieth centuries and document the responses of beekeepers, entomologists, and government officials to these concerns. Through toxicity studies and observations of honeybee behaviour, entomologists and beekeepers "read" the bodies their bees to better understand honeybee working environments and the opportunities and threats they presented.

This chapter examines three significant episodes of change in the working environments of honeybees in the late nineteenth and early twentieth centuries, and the responses these changes generated among their keepers:

1. changes in the diversity and extent of bee forage in the context of industrializing agricultural production;
2. the advent and spread of American foulbrood (AFB), a highly contagious bacterial disease of honeybee larvae that devastated North American beekeepers in the late nineteenth and early twentieth centuries; and
3. rising incidents of honeybee poisoning due to growing insecticide use in the same period.

In the following pages, I read between the lines of beekeeper records to glimpse honeybees as historical creatures in their own right, whose relative freedom and changing ability to thrive prompted specific and vigorous responses by their keepers. An appreciation of honeybees as historical actors illuminates changes in honeybee behaviour and vitality over the course of my period of study, as they responded to new pathogens and poisons and declining or homogenizing forage sources. These changes can be discerned through the concerns, actions, and decisions of beekeepers, who learned about environmental risks in surrounding landscapes through the behaviours and bodies of their bees. Bees provided information to their keepers not only in life, through the direction of their flight and the flowering plants they chose to frequent, but also in death, as their bodies became data sources for toxicity studies and, less frequently, litigation. At the root of these threats to honeybee health, and beekeeper livelihoods, lay the nature of honeybees as semi-domesticated animals with a fundamental freedom to forage.

Changing Sources of Bee Forage

The work that honeybees[14] do (for themselves and for their human keepers) begins in the early spring, when adult female workers leave the hive to gather pollen and nectar from flowering trees and plants. Beekeepers have historically called these kind of plants "bee forage" or "bee pasture," drawing deliberate connections between the honeybees they tend and other forms of livestock as a way of asserting their legitimacy as agricultural producers. A female worker makes roughly a dozen foraging trips daily in fair weather, typically within a three-kilometre range of the hive. She uses her straw-like tongue, or proboscis, to reach inside the flower, sucking up the sugary nectar into her "honey stomach," a second stomach used only for nectar. Here, the nectar mixes with enzymes that transform its chemical composition and pH to make it more suitable for long-term storage. She then moistens the hairs on her front legs and uses them to brush and compress the flower pollen clinging to her body into the "pollen baskets" on her back legs. When her honey stomach is full, she returns to the hive and regurgitates the nectar to share with other female workers, who chew the nectar to break down the sugars and evaporate some of the water. The bees then store the nectar in honeycomb cells—like tiny jars made of wax—fanning it with their wings to dry it further before sealing the cell with a wax lid to keep it clean. They draw upon the resulting stores of honey to feed their brood and nourish the colony over winter.[15]

Beekeepers, then and now, take advantage of these accumulation and storage activities by harvesting the surplus honey that honeybees create. Standard commercial box hives, whose design has not changed markedly since the 1850s, comprise a series of stacked compartments or "supers," each with frames upon which bees build their honeycomb. As the bees fill up these "supers" with honey for the winter, the keepers harvest the surplus, taking care to leave enough for the bees (or, as is common in commercial operations, supplementing stored honey with sugared water in fall and winter). One colony of 40,000–50,000 bees typically produces about ten kilograms of "surplus" honey each year.

Beekeepers direct honeybee labour by locating hives adjacent to desirable forage sources and relocating hives as different plant sources come into bloom. Honey bears the flavour of the blossoms from which it is produced, and beekeepers deliberately select certain kinds of bloom to produce certain kinds of honey, from the delicate taste of wildflower or linden tree honey to the more acquired, earthy taste of buckwheat honey. This ability to produce single-source variations of honey is aided by the tendency of honeybees to forage on one kind of flower on any single trip (a co-evolutionary strategy that also allows for cross-pollination of blossoms among a single plant species). A forager travelling to blackberry blossoms, for example, will keep going to blackberries until there are no more blackberry flowers, and then she will switch to something else. Foraging, it should be noted, is very hard work: it is the last in a series of tasks a worker bee performs in her five-to-eight week lifetime, and it is the most taxing. An average worker typically forages only four to five days before she dies.[16]

By the late nineteenth century, deforestation, urban development, and agricultural modernization across the Great Lakes region brought changes to the diversity and extent of forage sources. The first cause for concern was the flowering linden (or basswood) tree, which had become increasingly scarce throughout the region by the 1890s. Known commonly as the "bee tree," its highly aromatic blossoms provided an important source of nectar for struggling honeybee colonies in the spring and produced a highly prized "water-white" honey.[17] But soft, light-weight basswood was

Fig. 2.1 Blossom and leaf of the basswood (linden) tree. Source: Frank C. Pellett, *American Honey Plants: Together with Those Which Are of Special Value to the Beekeeper as Sources of Pollen* (Hamilton, IL: American Bee Journal, 1920), 33.

also valued for its suitability for a wide range of other products, from musical instruments to fruit baskets to window blinds. Alarmed beekeepers pointed to rapid declines of linden trees in urban and rural areas at annual meetings of beekeeping associations and in the columns of apicultural journals, calling for collective efforts to protect them. Ontario beekeeper Allen Pringle warned the members of the Ontario Beekeeping Association (OBA) in 1893: "the Linden tree is rapidly disappearing down the open and capacious maws of the pulp machines, the sawmills and the fallow fires. It is disappearing much faster than the uprising sprouts and saplings (spontaneous and cultivated) are taking its place." Another from Cincinnati encouraged beekeepers to "take up the chorus of plant! plant! plant! . . . [P]lant lindens on your roadsides, the division lines of your farms and unproductive hillsides."[18]

The growing scarcity of the linden tree was just the first of a series of changes that would significantly reduce wild sources of bee forage and dampen the viability of beekeeping in the region by mid-century. From the 1930s on, the expansion of commodity crops resulted in the steady disappearance of nectar-producing wildflowers, shrubs, and trees. New agricultural technologies and practices associated with the shift to monoculture production had unintended consequences for apiculture in the region. As Gordon Townsend, provincial apiarist for Ontario in the 1940s, recalled, the introduction of balers and forage harvesters in the 1930s and 1940s removed clover from fields before it came into bloom, and efforts to accommodate such large equipment resulted in the removal of hedgerows, another source of bee forage. Following World War II, crop scientists promoted continuous plantings of corn (which does not secrete nectar) on the same fields. Together with the routine spraying of roadside vegetation, according to Townsend, widespread continuous corn production "struck the final blow" to honey production from wild plant sources. These changes together led to dramatic declines in the diversity and abundance of bee forage in southern Ontario. Sweet clover, for example, an abundant source of bee forage in the 1920s and 1930s, declined by over seventy-five per cent from a peak of 400,000 acres in 1928 to less than 100,000 acres by 1947. "From that time on," Townsend concludes, "the decrease was so rapid that no statistical records were kept." Alsike clover, another major honey producer, declined by more than eighty-five per cent in the same period, and buckwheat, which covered 300,000 acres in 1929, "was almost nonexistent" by 1961.[19]

Reductions in bee forage had repercussions for the health of honeybee workers and the economic viability of their keepers. As experienced beekeepers know, fewer sources of forage reduce the longevity of individual workers by requiring them to fly longer distances on each foraging flight.[20] Knowledge from more recent studies of honeybee health tells us, too, that reductions in the diversity of forage sources had negative ramifications for honeybee nutrition. Honeybees harvesting nectar and pollen from a narrower range of floral sources contributed to reduced resilience in the face of other stressors, including disease, parasites, extreme weather conditions, and insecticide exposure.[21] These factors, combined with competition from western honey producers, contributed to a steady decline in the number of beekeepers and the viability of commercial operations from the 1930s on in Ontario and neighbouring US states.[22] Less nectar to gather and fewer operating beekeepers ultimately resulted in declining honeybee populations. In Ontario, for example, data from agricultural censuses shows that the number of honeybee colonies declined steadily from a peak of about 260,000 in the mid-1940s to less than 100,000 by 1973 and an average of 74,000 by the early 2000s.[23]

Exposure to Disease

If declining forage opportunities represented one change in honeybee working conditions, exposure to disease was another. For honeybees, susceptibility to disease transmission is exacerbated by their freedom to forage and by behavioural responses to nectar shortages. Foraging worker bees will collect sugary substances from any source they can find, including jars of honey or sugar syrup, honey collecting equipment, and in some circumstances, other honeybee colonies. In the late summer or early fall, when flowers are past their prime, nectar sources are scarce, and bees are hungry, foraging workers will seek out colonies that are smaller, weaker, or otherwise vulnerable to rob their honey stores. In just a few hours, a hungry forager can recruit a supporting crew of robbers from her own hive and overwhelm a weaker colony. Together they will fight resident bees to access and plunder their honey stores, and many bees die in the process.[24]

When an outbreak of American foulbrood (AFB), a deadly bacterial disease of honeybee brood, or larvae, struck Great Lakes apiaries in the late 1870s, beekeepers struggled to protect their worker colonies from infection. Long a scourge of beekeepers in Europe, and in North America from at least the 1670s, AFB is caused by spore-forming bacteria (another non-human actor in this story). Honeybee larvae eat the spores, which then grows like a mold and consumes the larvae. In cleaning the hive of dead larvae, adult worker bees spread the bacteria further.[25] Outside the hive, the disease can be spread through infected honeycomb and equipment, and by harvesting honey and pollen from infected hives.

Robber bees also spread AFB spores when they periodically rob the honey from infected hives. Colonies weakened by AFB are especially susceptible to attack, and in these attacks, disease is spread. Spores travel in plundered honey and on the bodies of robber bees returning from diseased hives. Once contracted, AFB will destroy a colony: while it does not affect adult bees, the destruction of the brood eliminates the possibility of replacement when adult workers reach the end of their short, five-to-eight week life spans.[26] Because AFB is indiscriminate, affecting strong and weak colonies equally, it carries the potential to destroy apiaries within a three- to eight-kilometre range (the flight range of foraging workers) of infected hives.

Honeybee colonies struggling with an AFB infection produce less honey. As worker numbers dwindle and more of the colony's energy is devoted to removing dead brood, fewer workers are available to gather and process floral nectar. Weakened colonies also struggle to fend off apiary pests like wax moths, which feed on honeycomb. Beekeeper sources for Ontario show, for example, that honey production declined by over forty per cent between 1891 and 1901. These changes were the product not only of honeybee mortality (the number of colonies in the province dropped by twenty per cent in this period), but also of reduced productivity in surviving colonies.[27]

Early responses to the disease by beekeepers often had the unwanted effect of exacerbating its spread. In the 1880s, deficits of knowledge about the nature of the disease and the absence of coordination between beekeeping organizations meant beekeepers were too often unsupported in their efforts. For many, detection came too late to remedy the problem. Others attempted to rid their colonies of disease by physically shaking adult bees onto new, uncontaminated hive frames. The "shaking" method, however, like other "sanitary" responses advocated in this period before germ theory was widely understood, sometimes did more harm than good. While some experienced beekeepers publicized their success, others struggled to replicate their methods and ran the risk of further spreading the disease.[28] Like Hodgins' livestock farmers (Chapter 5), beekeepers struggled to respond to a novel problem with often ill-suited or outdated practices. The hardiness of AFB spores, furthermore—they can survive for more than forty years in honey and beekeeping equipment—meant it wasn't long before bee colonies became reinfected.[29] By the early 1900s, entomologists and state beekeeping associations agreed that the best solution was to burn infected colonies, contaminated hives, and equipment—a devastating and expensive proposition for beekeepers.

Another response to the disease involved controlling the movement of honeybee workers. As Olmstead and Rhode have shown for crop science in this period, close study of the habits of insects and the nature of disease allowed farmers and scientists to achieve some "remarkable successes" in controlling biological hazards in the decades before the emergence of chemical controls. In an effort to prevent robbing of infected hives, beekeepers devised ways to close hive entrances with wire mesh or to deter intruders by stuffing entrances with grass. A wet blanket draped over the hive was another method used to discourage robbing while allowing the passage of resident bees. Producer associations and state and federal regulatory institutions developed important supports. To control honeybee movement over longer distances, beekeeping associations pressed for quarantines of infected apiaries and legislation prohibiting the import and sale of bees on honeycomb, wherein AFB spores could lie dormant. Ontario required permits for local honeybee sales from 1906 on; in 1923, it passed legislation prohibiting the import of bees and beekeeping equipment, with the exception of honeybee queens. By 1925, five US states, including Michigan and Illinois, had passed similar legislation for interstate and international imports and a further twenty-five required health certificates before bees on comb could enter the state.[30]

Responses by beekeepers to the threat of AFB infection in the 1880s and 1890s had the effect of re-articulating beekeeping organization and practice throughout the Great Lakes region and beyond. The need for a coordinated response to AFB and other honeybee diseases resulted in the establishment of provincial- and state-level beekeeping associations to support local and regional organizations. AFB dominated the agenda, for example, of the OBA's second annual meeting in 1882.[31] Reflecting similar developments in plant disease control and livestock inspection in the same period, state and provincial beekeeping associations appointed foulbrood inspectors to inspect and destroy infected hives.[32] In the OBA annual reports and weekly issues of the *American Bee Journal* in this period, foulbrood inspectors detailed the number of infected colonies identified and destroyed. They also documented their encounters with obstreperous apiarists who resisted the reach of state inspectors on their property and the economic losses that accompanied burned hives and equipment. Concern about disease transmission ultimately led to the passage of state and provincial legislation obligating beekeepers to immediately report cases of diseased hives and to cooperate with state or beekeeper association inspectors in eradicating the disease.[33]

By the 1910s, responses by beekeepers and state agricultural authorities had begun to make some headway. Changes in Ontario's foulbrood legislation in 1906 expanded government-sponsored inspection services six-fold, replacing a lone foulbrood inspector with six area-based inspectors. The introduction of mandatory burn requirements for infected hives in this period also bore out in modest signs of recovery. The 1911 agricultural census showed a six per cent increase in honeybee colonies from 1901, and, significantly, a forty-four per cent increase in worker productivity (honey production) over the same period. By 1925, Ontario, Michigan, and Illinois led the way in adopting "area clean-up" methods, which combined the destruction of all diseased colonies in a designated area with a three-year period of quarantine and regular inspection. Ontario destroyed fifty-eight per cent of inspected colonies when the program began in 1926; by 1929, only two per cent of inspected colonies were infected. By 1940, these combined practices of thorough inspection, burning, and quarantine reduced disease rates to less than three per cent across the Great Lakes region. The introduction of sodium sulfathiazole, an antibiotic that slowed the growth of foulbrood bacteria, gave a further boost to AFB control efforts by allowing individual beekeepers to treat diseased colonies at the first sign of infection, with less reliance on the inspection system.[34]

The virulence of AFB in the Great Lakes region in the late nineteenth and early twentieth centuries created disease environments that threatened the health of honeybee workers and the economic viability of the apiaries within which they laboured. Honeybees' freedom to forage, and their tendency to rob weakened or infected hives of honey stores, made disease control especially challenging for beekeepers. The coordinated responses that beekeeping associations and state agricultural authorities developed at the provincial and state level reconfigured beekeeping practice, introducing legislation and inspection that laid the foundation for state apicultural authorities in the post-war period. Inspection services not only brought the disease under control, but also educated individual beekeepers on effective disease diagnostics and early responses. By the 1930s, these changes significantly reduced the risk of disease contraction and spread for foraging honeybees.

Exposure to Insecticides

Perhaps the most pernicious of risks that honeybees faced on their foraging flights was exposure to insecticides. The danger was especially high

Fig. 2.2 Spraying fruit trees with a horse-powered spray jig near Ayr in southwestern Ontario, ca. 1910. Source: Robinson Studio Photographs Fonds F4592-7, H-1015, Archives of Ontario.

in the industrializing orchards of the region, where mounting challenges with insect pests had prompted fruit growers to experiment, beginning in the 1870s, with the application of arsenic-based insecticides.[35] The effectiveness of these insecticides in improving yields of marketable fruit, coupled with advocacy for their use by influential entomologists and state horticultural officials, led growers across the region to apply ever-increasing quantities of insecticidal sprays to apples and other orchard crops.

Foraging honeybees began encountering orchard blossoms sprayed with Paris Green (aceto-arsenite, a highly toxic copper-arsenite) with greater frequency beginning in the late 1880s; by the early 1900s, they were more likely to encounter the sticky and even more lethal residues of lead arsenate. Foragers that ingested the poison through contaminated nectar or water sources were likely to die in the field, before reaching the hive. For those that carried contaminated pollen back to the hive, the damage was much more extensive. Pollen contaminated with arsenical insecticide remains toxic for months, killing both the nurse bees that ingest the pollen to feed it to the brood, and the brood bees as well. Poisoned bees experience distended abdomens, diarrhea, and an inability to fly. Poisoned nurse bees, for example, will often attempt to leave the hive, fly a short distance, and end up hopping or crawling on the ground in front of the hive.[36]

One of the earliest reported incidents of insecticide poisoning was related by beekeeper John G. Smith of New Canton, Illinois, in the 25 May 1889 issue of the *American Bee Journal*. The apple bloom that year, he reported, proved a "'death-warrant' to millions of bees in [his] immediate neighbourhood" when the owner of a neighbouring orchard sprayed his trees with a solution of Paris Green when the trees were in full bloom.[37] Smith lost sixty of his own honeybee colonies, and by his estimate "ten or twelve bee-keepers" in the area surrounding the orchard were "totally ruined, as far as getting a spring crop of honey [was] concerned."[38]

Faced with the impossibility of containing their bees, beekeepers on both sides of the border made collective efforts to mitigate the risks within honeybee working environments. Early investigations established the toxicity of arsenate insecticides to honeybees[39] and confined the problem to the timing of the spray: honeybees visited fruit-tree orchards to forage for nectar and pollen only when the trees were in bloom. Their exposure to risk was limited to a brief, two-week window when the blossoms still clung to the branches, before the fruit began to form. State entomologists and prominent beekeepers proposed a simple solution: refrain from spraying during the bloom.

Doubts persisted, however, among growers reluctant to circumscribe their activities, and scientists enamoured with the results of insecticide use. Despite efforts to educate neighbouring growers about the risks of insecticide use and the value of honeybee pollination to their operations, poisoning incidents continued. With limited avenues to recoup their losses, beekeepers turned increasingly to legislative tools for protection.

Ontario was the first to pass protective spraying legislation. In the spring of 1892, a month before the publication of Cook's first toxicity study, a delegation from the OBA to the Ontario Ministry of Agriculture resulted in the passage of *An Act for the Further Protection of Bees*. The

Act—the first of its kind in North America—stipulated that fruit trees could be sprayed only *after* the bloom had fallen, thereby protecting bees from harm.[40] Several US states followed, passing legislation similar to Ontario's, including Michigan and Vermont (1896), Colorado (1897), and New York and Washington State (1898). Others, including Ohio, Illinois, and California, had spraying bills rejected in response to counter-lobbying by fruit-growing interests.[41]

Growers expressing their opposition to spraying legislation sometimes made direct comparisons to protective legislation for human workers in the same period. In 1890, editors of *American Garden* railed against beekeeper advocacy for a spraying law in Michigan: "Surely, fruit is of more importance than honey! If those busy workers must have [l]egislation, let us advocate a training school for bees, in which they may be taught to keep out of the orchards at the dangerous period."[42] Like Chris Sellers' conclusions for human exposure to workplace toxins in the same period, modifying worker behaviour or access to toxic environments was seen as preferable to ensuring safe working conditions.[43] If trespass laws applied to cows and other domesticated animals, the editors concluded sardonically, why should they not be applied to bees? Their commentary pointed to two central challenges at the heart of the spraying debates: the fundamental "uncontainability" of bees as semi-domesticated foraging insects; and the limited and variable knowledge of growers about the value of honeybee pollination to the orchard. At a time when the role of bees in fruit pollination was not widely understood, bees were often viewed more as an enemy than an aid to the orchard.[44] Honeybee labour, freely offered, was often under-appreciated by growers.

In the end, legislation, however promising, proved difficult to enforce.[45] Beekeepers made greater headway in demonstrating the value of honeybee labour to crop production in neighbouring orchards than they did in advocating for legislation. A series of pollination studies conducted by supportive entomologists in the 1890s demonstrated conclusively that trees in full bud exposed to honeybee pollination produced exponentially more fruit than unexposed trees.[46] In 1894, for example, USDA entomologist Merton B. Waite proved that for pears "the common honey-bee is the most regular, important and abundant visitor, and probably does more good than any other species."[47]

The dissemination of expert opinion by horticultural scientists such as Waite in respected horticultural magazines, such as *Better Fruit* and *Green's Fruit Grower*, helped to raise awareness about the role of honeybees in pollination. Coupled with advocacy efforts by beekeeping associations, it also reduced the frequency and severity of poisoning incidents. By the turn of the century, beekeepers could feel more confident that their bees could forage in neighbouring orchards without risk of poisoning. Commentators at a Beekeepers' Convention in Chicago in April 1898, for example, praised "the horticultural societies and newspapers" for "[taking] up the subject so thoroughly that almost all who do spray now will spray at the proper time."[48] Ignorant or malicious activities continued, but as the exception rather than the norm.

As orchardists intensified production in the early twentieth century, however, increases in the frequency and quantity of insecticide applications, coupled with the introduction of new compounds (lead arsenate replaced Paris Green by the 1900s, and a host of synthetic insecticides became available in the 1940s), forced beekeepers to engage in what would become cyclical debates about the timing of the spray and the toxicity of ever-new insecticidal compounds to honeybee workers.

Conclusion

In each of these instances—declining forage sources, exposure to disease, and insecticide poisoning—beekeepers learned about environmental risks in surrounding landscapes through the behaviours and bodies of their bees. The concerns they reported, and the evidence they produced, allow me to interpret changes not only in their own ability to thrive as marginal agricultural producers, but also in the behaviour and vitality of the animals they kept. As working animals who formed a nexus between industrializing environments and human producers and consumers, honeybees provide useful indicators of environmental change. Unlike the thousands of native bee species that occupy the North American continent, whose history is largely obscure to us, honeybees were and are animals whose health and numbers were monitored and recorded. Through the surviving records of beekeeper associations, entomologists, and state agricultural agencies, we can document the mounting environmental stresses on these animals, and the resulting economic vulnerability of their keepers.

As Linda Nash has shown for the industrializing landscapes of central California, the bodies of human workers changed environments, and environments, in turn, changed workers' bodies, compromising their health.[49] My sources demonstrate that this was also the case for animal workers. The modernization of agriculture in the Great Lakes region between 1880 and 1940 brought what historians Alan Olmstead and Paul Rhode have described as an inevitable acceleration of pests and diseases as time passed and plantings intensified.[50] Honeybees were not only the unintended targets of responses to insect outbreaks by neighbouring farmers, they also became increasingly subject to disease risks and pests of their own, in the form of mites and other parasites. Changing environmental circumstances, such as reductions in the use of clover as a fallow crop and the loss of lindens and other flowering trees from roadsides and hedgerows, reduced honeybee resilience and made honeybees and their keepers more susceptible to other risk factors and to seasonal variations such as drought, late frost, or heavy rainfall.

The extent to which I can read the experience of honeybees in the records of their keepers relies in large part on the specialized environmental knowledge and sharpened powers of observation common to apiarists. Nineteenth- and early twentieth-century beekeepers provided such useful sources for my study, in other words, because they were themselves attentive to their bees as sources in their own right. In life, and in death, honeybees provided valuable information. In life, the landscapes they navigated and the types of nectar they harvested influenced the taste and quality of the honey they produced, and beekeepers paid attention to these pathways. As much as bees communicated with each other, performing the "waggle dance," for example, to describe the location of forage sources, they also provided information to their keepers through the direction of their flight. Observant beekeepers like John Smith could determine from the flight paths of their bees not only the location of forage sources, but also the origins of insecticide poisonings. In death, the bodies of bees confirmed or refuted suspicions in toxicity studies and served in rare instances as the basis for litigation and compensation claims.[51]

By concentrating on the labour and working conditions of honeybees, I have attempted to get closer to a honeybee's experience of environmental changes in this period. But recent advancements in scientific understanding of honeybee behaviour highlight the limits of this conceit. Studies have shown that female foragers not only communicate their findings to other workers, but also respond to the communication devices of the floral landscapes they forage within. Flowers attract bees with colourful petals, welcoming "landing platforms," and distinctive patterns called "nectar guides" that are often invisible to humans. Sunflowers, primroses, and pansies, for example, produce nectar guides that are only visible in ultra-violet light: unseen by humans but extremely attractive to pollinators.[52] Other flowers signal to bees by refracting light to cast an attractive "blue halo" over their blooms.[53] Just as beekeepers "read" the bodies and behaviours of their bees, bees themselves read flowers as texts to understand their working environments. Scent is another factor: a foraging worker may avoid a particular flower because she can smell the odour of the previous foraging bee.[54] Thus, while honeybee labour is certainly part of the story—fewer foraging sources, for example, mean longer flight distances and reduced longevity for individual workers—history from the honeybee's perspective might best be written in stories of odours familiar and strange, and of diminishing reflections of welcome blue light.

NOTES

1 Thanks to the two anonymous reviewers and Dolly Jørgensen, Sean Kheraj, Claire Campbell, Melanie Kiechle, and Andy Robichaud for their thoughtful comments on earlier versions of this paper. Research for this chapter was made possible with support from Canada's Social Sciences and Humanities Research Council.

2 Jason Hribal, "'Animals Are Part of the Working Class': A Challenge to Labor History," *Labor History* 44, no. 4 (November 2003): 435–53.

3 Joshua Specht joins others in recommending that agency "should always be the start of the analysis, rather than the conclusion of the argument" in "Animal History after Its Triumph: Unexpected Animals, Evolutionary Approaches, and the Animal Lens," *History Compass* 14, no. 7 (2016): 332.

4 Scholars in animal behaviour sciences have made some headway on studies of animal intelligence in recent decades. See, for example, Edward A. Wasserman and Thomas R. Zentall, eds., *Comparative Cognition: Experimental Explorations of Animal Intelligence* (London: Oxford University Press, 2009).

5 Donna J. Haraway, *When Species Meet* (Minneapolis: University of Minnesota Press, 2008), 55; Edmund Russell, "Can Organisms Be Technology?" in *The Illusory Boundary: Environment and Technology in History*, ed. Martin Reuss and Stephen H. Cutcliffe (Charlottesville: University of Virginia Press, 2010), 249–62. As Haraway reasons,

positioning working animals as labourers within a capitalist system is "more than an analogy, but it is not an identity." Working dogs, for example, are "paws, not hands." Following Russell, she argues that "organisms shaped for functional performance in human worlds" might best be understood as "biotechnologies," biological tools "shaped by humans to serve human ends." Honeybees differ from dogs, however, in the extent to which their genetics have been shaped by humans. Unlike dogs and other domestic animals, which have been selectively bred by humans for thousands of years, honeybee breeding was not successfully controlled by humans until the advent of instrumental insemination techniques in the 1940s. Furthermore, selective breeding does not "stick" for honeybees in the same way it does for dogs. Despite the ability to produce gentler, more productive or more resilient stock through controlled breeding of queens, the benefits of breeding quickly dissipate when the daughters of these queens mate freely with "open stock." As Rusty Burlew observed in a 2018 article in the *American Bee Journal*, "within a generation or two, the descendants of these super bees are right back to square one." As a result, honeybee "races" (including Caucasians, Carniolans, and Italians) have much greater genetic variability than other breeds of domestic animals. Rusty Burlew, "Honey Bee Genetics: Why Breeding is So Difficult," *American Bee Journal* (August 2018), https://americanbeejournal.com/honey-bee-genetics-why-breeding-is-so-difficult; John R. Harbo and Thomas E. Rinderer, "Breeding and Genetics of Honey Bees," *Beekeeping in the United States,* Agricultural Handbook No. 335 (US Department of Agriculture: October 1980), 49–57, https://beesource.com/resources/usda/breeding-and-genetics-of-honey-bees/.

6 In both Canada and the United States, honeybee colonies are enumerated as economic units of production, or resources, in agricultural censuses.

7 Clay McShane and Joel A. Tarr, *The Horse in the City: Living Machines in the Nineteenth Century* (Baltimore: Johns Hopkins University Press, 2007). See also Ann Norton Greene, *Horses at Work: Harnessing Power in Industrial America* (Cambridge, MA: Harvard University Press, 2008). For ecologically inflected analyses of risk in human working environments, see Christopher C. Sellers, *Hazards of the Job: From Industrial Disease to Environmental Health Science* (Chapel Hill: University of North Carolina Press, 1997) and Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: University of California Press, 2007).

8 See, for example, Timothy J. LeCain's discussion of silkworms in *The Matter of History: How Things Create the Past* (Cambridge, MA: Cambridge University Press, 2017). Virginia Anderson, Ted Steinberg, Catherine McNeur, and Andrew A. Robichaud have explored the ways that free-ranging pigs in rural colonial and later urban environments performed a kind of labour that humans profited from, converting household and urban waste into meat for human consumption. Anderson, *Creatures of Empire: How Domestic Animals Transformed Early America* (New York: Oxford University Press, 2004); Steinberg, *Down to Earth: Nature's Role in American History* (New York: Oxford University Press, 2002); McNeur, *Taming Manhattan: Environmental Battles in the Antebellum City* (Cambridge, MA: Harvard University Press, 2014); Robichaud, *Animal City: The Domestication of America* (Cambridge, MA: Harvard University Press, 2019).

9 Richard White, *The Organic Machine: The Remaking of the Columbia River* (New York: Hill and Wang, 1995). Recent work on the Anthropocene employs White's approach to consider the blend of human labour and capital with non-human fossil

fuel energy sources. See, for example, Andreas Malm, *Fossil Capital: The Rise of Steam Power and the Roots of Global Warming* (London: Verso, 2016); and Jason W. Moore, ed., *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism* (San Francisco: PM Press, 2016).

10 Thomas G. Andrews, *Killing for Coal: America's Deadliest Labor War* (Cambridge, MA: Harvard University Press, 2008), 125.

11 Haraway, *When Species Meet*, 55. Sean Kheraj has described relationships between humans and domestic animals as a form of "asymmetrical symbiosis" in his "Animals and Urban Environments: Managing Domestic Animals in Nineteenth-Century Winnipeg," in *Eco-Cultural Networks and the British Empire: New Views on Environmental History*, ed. James Beattie, Edward Melillo, and Emily O'Gorman (London: Bloomsbury, 2015): 263–88.

12 On Texas longhorn cattle, see Richard White, "Animals and Enterprise," in *The Oxford History of the American West*, ed. Clyde A. Milner II, Carol A. O'Connor, and Martha A. Sandweiss (New York: Oxford University Press, 1994), 237–73; and Joshua Specht, "The Rise, Fall, and Rebirth of the Texas Longhorn: An Evolutionary History," *Environmental History* 21, no. 2 (April 2016): 343–63.

13 For a more detailed discussion of industrializing organisms, see Philip Scranton and Susan R. Schrepfer, eds., *Industrializing Organisms: Introducing Evolutionary History* (New York: Routledge, 2004).

14 The Western honeybee (*Apis mellifera*) is just one of the over 4,000 species of bees in North America. Unlike its wild counterparts, *Apis mellifera* was introduced from Europe, following (and according to some accounts by Indigenous peoples, often preceding) frontiers of European colonization. It is one of only two species of bees (the other, the Indian honeybee, *Apis cerana indica*) that has been domesticated for human agricultural production.

15 Mark Winston, Chapter 10: "The Collection of Food," in *The Biology of the Honey Bee* (Cambridge, MA: Harvard University Press, 1991).

16 Worker lifespans depend on seasonal factors, food availability, and the intensity of work they perform: while highly active summer brood typically live fifteen to thirty-eight days, those born in spring and fall live as long as thirty to sixty days, and those that remain mostly inactive over winter survive as long as 140 days. Winston, *The Biology of the Honey Bee*, 55, 101.

17 T. R. Crow, "*Tilia Americana L.,* American Basswood," in *Silvics of North America*, vol. 2, *Hardwoods*, ed. Russell M. Burns, and Barbara H. Honkala (Washington, DC: United States Forest Service, 1990), https://srs.fs.usda.gov/pubs/misc/ag_654/volume_2/tilia/americana.htm; Frank C. Pellett, *American Honey Plants: Together with Those Which Are of Special Value to the Beekeeper as Sources of Pollen* (Hamilton, IL: American Bee Journal, 1920): 32–33.

18 Allen Pringle, "Apiculture at the World's Fair," *OBA Annual Report* 1893, 29–30; Henry K. Staley, "Forestry and Apiculture," *American Bee Journal* 28, no. 25 (December 1891), 781–82.

19 Gordon F. Townsend and Henry Theo T. Hiemstra, *History of Beekeeping in Ontario* (Milton: Ontario Beekeepers' Association, 2006), iii–iv.

20 Winston, *The Biology of the Honey Bee*, 101.

21 Dhruba Naug, "Nutritional Stress Due to Habitat Loss May Explain Recent Honeybee Colony Collapses," *Biological Conservation* 142, no. 10 (October 2009): 2369–72; Winston, *The Biology of the Honey Bee*, 55.

22 Like Ontario, which saw its dominance in apiculture eclipsed by western provinces from the 1930s on, New York, Ohio, Illinois, and other Great Lakes states saw their production overshadowed by California, Colorado, and other western states by mid-century. Stoll, *The Fruits of Natural Advantage*, 52–54; United States Department of Agriculture, Census of Agriculture 1920, 686–89; Townsend and Hiemstra, "*History*," 85; M. B. Holmes, "Progress of Beekeeping in Canada," *American Bee Journal* 37, no. 51 (December 1897): 802.

23 Statistics Canada, Table 32-10-0353-01: "Production and value of honey," annual, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3210035301, accessed May 1, 2020. Similar declines in colony numbers are apparent in New York State beginning in the mid-1950s (USDA, National Agricultural Statistics Service, "Honey Production and Value, 1939–2007.") See also Dennis van Engelsdorp, and Marina Doris Meixner, "A Historical Review of Managed Honey Bee Populations in Europe and the United States and the Factors That May Affect Them," *Journal of Invertebrate Pathology* 103 (January 2010): S80–95.

24 Ryan Willingham and Jeanette Klopchin, "Robbing Behavior in Honey Bees," *Entomology and Nematology* (August 2018), https://edis.ifas.ufl.edu/in1064; Winston, *The Biology of the Honey Bee*, 115.

25 Tammy Horn, *Bees in America: How the Honey Bee Shaped a Nation* (Lexington, KY: University Press of Kentucky, 2006): 37, 66.

26 Francis L. W. Ratnieks, "American Foulbrood: The Spread and Control of an Important Disease of the Honey Bee," *Bee World* 73, no. 4 (1992): 177–91; Willingham and Klopchin, "Robbing Behaviour."

27 Townsend and Hiemstra, "History," 93.

28 Townsend and Hiemstra, 119–20, 123.

29 Horn, *Bees in America*, 37.

30 M. G. Dadant, "Distribution of American Foul Brood," *American Bee Journal* 66, no. 9 (September 1926): 429; Townsend and Hiemstra, "History," 120–22.

31 Townsend and Hiemstra, "History," 117; Dadant, "Distribution of AFB," 429–31.

32 For comparable developments in plant and livestock disease control, see Lise Wilkinson, *Animals and Disease: An Introduction to the History of Comparative Medicine* (London and New York: Cambridge University Press, 1992); and Alan L. Olmstead and Paul W. Rhode, *Creating Abundance: Biological Innovation and American Agricultural Development* (New York: Cambridge University Press, 2008).

33 Michigan was the first to pass disease control legislation in 1881. Ontario was next with the passage of its *Act for the Suppression of Foulbrood among Bees* in 1889. Other Great Lakes states followed: New York in 1893, Wisconsin in 1897, and Ohio in 1904. By the 1920s, all but a handful of US states had passed legislation to prevent the spread of AFB. See Townsend and Hiemstra, "History," 120; *Recent Laws Against Insects in North America: Together with the Laws Relative to Foul Brood*, US Department of Agriculture,

Division of Entomology, 1898; *The Laws in Force Against Injurious Insects and Foul Brood in the United States*, US Department of Agriculture, Bureau of Entomology, 1906.

34 Dadant, "Distribution of AFB," 430; Townsend and Hiemstra, "History," 126. Sodium sulfathiazole prevents the growth of AFB bacteria but does not destroy the spores that cause its spread. While it gave beekeepers an important tool in AFB control, the development of resistant strains of AFB bacteria ultimately reduced the effectiveness of sulfa drugs and other antibiotics. Today, burning diseased colonies and equipment is still considered the most effective remedy.

35 I examine the relationship between orchardists and beekeepers in greater detail in "Early Insecticide Controversies and Beekeeper Advocacy in the Great Lakes Region," *Environmental History* 26, no.1 (January 2021): 79-101, https://doi.org/10.1093/envhis/emaa059. See also James Whorton, *Before Silent Spring: Pesticides and Public Health in Pre-DDT America* (Princeton, NJ: Princeton University Press, 1974); and George M. Cook, "'Spray, Spray, Spray!' Insecticides and the Making of Applied Entomology in Canada, 1871–1914," *Scientia Canadensis* 22, no. 51 (January 1998): 7–50.

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37 John Smith, "Ruined by Paris Green," *American Bee Journal* 25, no. 21 (May 1889): 331.

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42 S. I. Freeborn, "Spraying Trees: Some Foolish Advice Given by Editors," *American Bee Journal* 26, no. 4 (January 1890): 53–54.

43 Sellers, *Hazards of the Job*.

44 Whorton, *Before Silent Spring*, 27.

45 Holtermann, "Spraying Fruit-Trees," 277.

46 See, for example, Prof. V. H. Lowe's studies at the Geneva Experiment Station in 1899 (referenced in E. R. Root, *The Bee-Keeper and the Fruit-Grower*, 1920 edition, 7).

47 Merton B. Waite, "Pollination of Pear Flowers," Bulletin No. 5, USDA, 1894, cited in A. J. Cook, "Bees and Pollination of Blossoms," delivered to S. CA Pomological Society at Pasadena. *American Bee Journal* 33, no. 22 (May 1894): 694–96.

48 *American Bee Journal* 38, no. 14 (April 1898): 213.

49 Nash, *Inescapable Ecologies*.

50 Olmstead and Rhode, *Creating Abundance*.

51 Bonnell, "Early Insecticide Controversies."

52 Sharla Riddle, "How Bees See and Why it Matters," *Bee Culture*, May 20, 2016, https://www.beeculture.com/bees-see-matters/.

53 Nicola Davis, "Flowers use 'blue halo' optical trick to attract bees, say researchers," *The Guardian*, October 18, 2017, https://www.theguardian.com/science/2017/oct/18/flower-nanostructures-optical-trick-attract-bees-pollinators-blue-halo.

54 ScienceDaily, "Honey Bee Chemoreceptors Found For Smell And Taste," accessed May 1, 2020, https://www.sciencedaily.com/releases/2006/10/061025181706.htm.