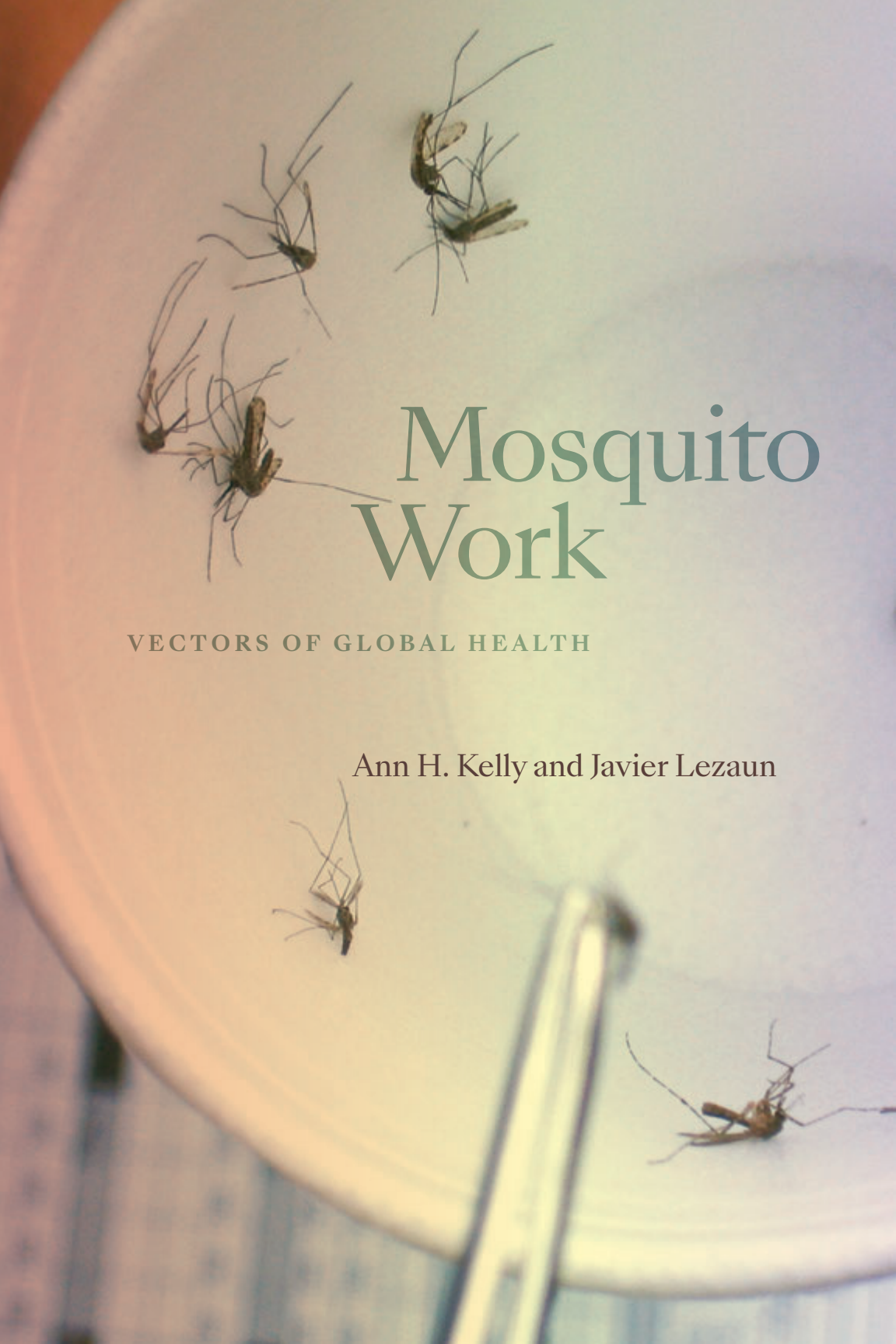

Mosquito Work

VECTORS OF GLOBAL HEALTH

Ann H. Kelly and Javier Lezaun

Mosquito Work

CRITICAL GLOBAL HEALTH: EVIDENCE, EFFICACY, ETHNOGRAPHY

A series edited by Vincanne Adams and João Biehl

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Vectors of Global Health

ANN H. KELLY AND JAVIER LEZAUN

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Cover art: Sampling mosquitoes in Lupiro, Tanzania, 2008. Photo by authors.

For Oskar and Imanol
In Memory of Bridget Gellert Lyons

Contents

Preface

One of our favorite bits of entomological lore involves Fredros Okumu. A world-leading vector biologist, Fredros likes to tell how, at the start of his career, he asked Bill Gates for one of his socks. He had been awarded a sizable grant from the Gates Foundation to investigate which foot emanations are most attractive to *Anopheles* mosquitoes—foot odor being irresistible to blood-seeking females. Perhaps, Fredros wondered, in addition to the money he could also obtain research material from the Foundation's founder?

Fredros's curiosity about mosquito olfaction built upon the insights of Bart Knols, a larger-than-life Dutch scientist who mentored Fredros when he was a student. Knols had investigated the predilection of malaria-carrying *Anopheles* mosquitoes for feet emanations by sitting naked on a stool in an insectary and then recording how bites clustered on and below his ankles.[1] Through further chemical analysis, he was able to link the scent given off by his own feet to that of Limburger cheese—which, it turns out, is produced by bacteria belonging to the same genus as those that flourish between our toes.

The prospect of a barefoot entomologist wielding ripe wheels of cheese generated considerable amusement from the scientific community (culminating in the award to Knols of the 2006 Ig Nobel Prize for Biology, a celebration of "achievements that first make people laugh, and then make them think"). But not much by way practical insight came out of these findings until Fredros isolated the eight essential chemicals that constitute sweaty foot pong at its most potent.[2] After an arduous process of chemical distillation, tweaking dosages and concentrations on dipped strips of nylon stocking, he landed on a blend that proved almost five times as alluring as the real thing. This synthetic formulation was then used in a new generation of odor-baited traps, which lure *Anopheles*

mosquitoes away from human hosts and in doing so provide a measure protection against malaria.[3]

Fredros received much media attention and accolades for this work. He was heralded by Peter Singer, the then-CEO of Grand Challenges Canada, as "a great example of an African innovator with an African innovation, tackling an African problem."[4] Since the moment we met him as a doctoral student, Fredros's prodigious scientific talent was patently obvious. Through the privilege of working with him and his team in subsequent years, we also came to appreciate his ingenuity in pioneering locally designed disease control interventions. But there is something off in Singer's praise—a provincialism that fundamentally mischaracterizes Fredros's project and underestimates its public health promise. For Fredros's ambitions have always been cosmopolitan—in 2016, for example, when he was director of science at Ifakara Health Institute in Tanzania, Fredros was honored by *Foreign Policy* magazine as a "Global Thinker" for his design of low-cost mosquito repellent sandals that could be used to reduce the risk of Zika virus infection.[5]

What Fredros's work offers is a model of global health innovation defined by its proximity to the problems it seeks to address, a process that begins and ends in *the field* (figure FM.1). Those investigative coordinates represent a radical departure from the global health convention of intervening in "resource-limited or resource-poor settings." Rather than spaces of absence and need, *the field*, as Fredros practices it, marks the set of relationships that characterize a particular disease situation—relationships that, with the appropriate tools and some ingenious rearrangements, can also bring about its social transformation.

Anchored in almost two decades of ethnographic and historical investigations into entomological research and mosquito control efforts around the world, this book tracks the work and vision of the innovators, architects, and practitioners of what we might loosely call the "global health field." Our analysis draws from an ongoing engagement with an international network of entomologists and disease ecologists, and it spans the diversity of vector control research and interventions—including the design of new mosquito traps, the prolonged campaigns to eliminate breeding grounds across a large city, the seemingly old-fashioned efforts to "mosquito-proof" houses, and the contemporary laboratory research on gene drives and other mosquito modification technologies that promise to eradicate whole mosquito species.

Readers will find that the book's empirical tenor operates in a different register from that of a conventional social scientific account. Although its close-range descriptions, emotional attachments, and narrative commitments bear the hallmarks of ethnography, our investigative intimacy with our colleagues brings an

FIGURE FM.1. Fredros Okumu, Ifakara Semi-Field Station, 2008.

additional dimension. The perspectives we offer here are the offshoots of collaborative research, actualized in the joint preparation of grant proposals and research reports, refined through the writing of coauthored papers or the co-supervision of students, and tested in the formulation of public health protocols or the design of prototypes. If ethnography unfolds through a switching of perspectives, the oscillations between the foreign and familiar that Marilyn Strathern once characterized as "creating tangents," then the intellectual operations that drive our project are perhaps then best characterized as *coextensive*.[6] The book's lines of thought follow the questions and interests that preoccupy our entomological colleagues and thus, at times, may read as more immediately relevant to mosquito control than to social "theory," its analytical moves more akin to corroboration than critique.

We have been particularly drawn to the mechanics of mosquito work: the everyday operational challenges that this work must confront and the micro–material adjustments and sociopolitical accommodations through which those practices evolve. Our amazement with technical wizardry has been hard to contain, betrayed in all the moments when our account erupts in breathless detail—*Cheese volatiles! Olfaction! Naked on a stool! Bill Gates's stinky sock!*

Falling under the spell of entomology's madcap aesthetic carries some risk—the enchantment of technicity can easily diminish analytical insight. On this

point, the literary scholar Sianne Ngai is unflinching: "When criticism is written entirely from the point of view of artists and their technical problems," she writes, "it does not merely become dully technical; it ceases to be criticism, unable to exert judgment's pressure on art predefined by its terms."[7] We admit to being weary of exerting the pressure of our own judgment on the technical qualities of mosquito work, but we have tried to heed Ngai's underlying warning against collapsing critique into an ethnographic replica of the materials and methods section of a scientific paper. The transposition of entomological practice into anthropological description would ultimately be an abdication of interpretation—tantamount to a transdisciplinary gimmick, dazzling the otherwise scrupulous reader in an electric fetish of nylon stocking strips and microscopic parts.

Yet taking the time to recount the eclectic tools, experimental settings, and epistemic arrangements used to investigate the life-cycle of mosquitoes is in itself revelatory, a testament to the exquisite forms of care and labor required to bring these unruly creatures to global health attention. Here, we draw inspiration from Anna Tsing and colleagues in their call to "symbiotic scholarship" as a means of "slowing down to listen to the world—empirically and imaginatively at the same time," and "our only hope in a moment of crisis and urgency."[8]

In our case, the attraction of the entomological sublime is attenuated by the very purpose of these investigations. All the endless experimental attunements to mosquito preferences and behavioral eccentricities, the sprawling taxonomies of breeding grounds and mating habitats, the flight distances measured and wing tones recorded, the colonies nurtured over decades on dog biscuits and bottles of Evian—all those fastidious, painstaking attentions are oriented by a single question: *how best to kill* mosquitoes in order to prevent human death and suffering. Or, in the *sublethal* variations of this imperative (see chapter 4), how best to repel and distance so as to deny female mosquitoes the opportunity to bite humans and act as vectors of disease.

The paradoxical empirics of caring, killing, and distancing animate entomological inquiry, meted out in everyday efforts to apply its hard-won knowledge to the control of deadly infectious diseases. These efforts unfold under the mounting pressures of ecological change and emerging pathogens, shaped by the recalcitrance of the mosquito and the epidemiological consequences of structural inequities. Our critical attitude here is one of alliance, made possible by the generosity and intellectual responsiveness of our entomological colleagues, who have allowed us to participate in the formidable project of mosquito control. That privilege has meant foregoing a critical dialectics of interrogation and exposure to give ourselves over to the task at hand, whether helping to map breeding grounds or design a better trap. It has also demanded a different narrative

style, oriented by the stories entomologists tell about themselves and the tiny bodies circling their ankles and feet. This is then a project of creative curation—juxtaposing ethnographic and archival materials, jump cuts from the present to the past—intended to accentuate and amplify rather than dissect or deflate the values and concerns that animate our colleagues' practice.

Our debt to those communities of inquiry is overwhelming. From the generous introduction to the field of vector control extended by Steve Lindsay to the sustaining inspiration of Fredros Okumu, they have helped us understand the significance of their work for global health. Their hospitality, like that of the many other entomological colleagues we have had the pleasure of working with over the years, from Banjul, Dar es Salaam, and Bobo-Dioulasso to Barcelona, Sheffield, and Rio de Janeiro, far exceeded the conventions of interdisciplinary tolerance. They opened the doors of their insectaries and experimental huts, showed us how to count the stripes on the legs of the *Aedes albopictus*, and found a place for anthropological insight in their projects, transforming our capacities for ethnographic attention along the way. It is their spirit of genuine and serendipitous collaboration that we have tried to emulate in our research and to do justice to in the writing of this book.

We owe a particularly large debt to Heather Ferguson, Lina Finda, Emmanuel Kaindoa, Gerry Killeen, Salum Mapua, Sarah Moore, Irene Moshi, Winifrida Mponzi, Doreen Siria, and the truly remarkable team of public health entomologists and mosquito researchers at Ifakara Health Institute (IHI). We wish to make a special note of gratitude to Prosper Chaki, whose passing during the final stages of this book's completion is a loss we feel deeply. His commitment to rigorous public health research, grounded in long experience and a profound dedication to improving the lives of the most vulnerable, and his generosity as a mentor and collaborator shaped this project in enduring ways.

At Burkina Faso's Institut de Recherche en Science de la Santé (IRSS) in Bobo-Dioulasso, we benefited from the engagement and guidance of Léa Paré Toé, Nourou Barry, Simon Sawadogo, and Abdoulaye Diabaté. The generous group of historians, social scientists, and entomologists at the Fundação Oswaldo Cruz (Fiocruz) in Rio de Janeiro, including Gustavo Matta, Guilherme Borges da Costa, Denise Valle, and Denise Pimenta, broadened our book's ambitions and provided empirical provocations as well as models of public health compassion and care.

Research into the Soviet malaria eradication campaign would have been impossible without the help of Diliara Valeeva as well as the continual support of Anastasia Fedatova and the Soviet Environmental History Group. The archives at the Martsinovskii Institute of Medical Parasitology and Tropical Medicine,

the Wellcome Trust, the London School of Hygiene and Tropical Medicine, and the U.S. National Agricultural Library helped establish our historical footing, further grounded by the insights and reflections of Mark Benedict, Samuel Breeland, Derek Charlwood, David Dame, Seth Irish, Musa Jawara, Japhet Kihonda, Jo Lines, and Tony Wilkes—leaders of entomological research and mosquito control initiatives undertaken across multiple countries and over many years. In the later stages of writing, we had the good fortune of being involved in a set of initiatives at the intersection of climate change, vector control, and community-based design. David Weetman, Luca Facchinelli, and Frederic Bartumeus and his team enlivened us with the possibilities of crowd-sourced entomological intelligence. Liz McCormick, Yeromin Mlacha, Fatma Mohamed, Ibrahim Msuya, and Brook Muller pushed us to think about the radical potential of considering disease prevention as a problem of architectural design and thermal comfort. Conversations with Silas Majambere over the years taught us a deep attentiveness to the trade-offs between what can be learned and what needs to be done, right here and now. His friendship runs through this book like a red thread.

Our engagement with these colleagues has been supported by multiple funders, including the European Union (European Research Council and Horizon Europe), the Gates Foundation, the British Academy, UK Newton Fund, the Wellcome and Leverhulme Trusts, UK Research Councils and National Institute for Health Care Research, and the Brocher Foundation as well as internal grants from the University of Oxford and King's College London. The chapters that follow were gradually developed over a series of kind invitations to present our work at workshops and seminars including (but in no way exclusive to) "Contagion and Calculus" at the University of Edinburgh, "Aftermaths of the Scalar" at CNRS's CERMES-3, "Oikography" at the School for Advanced Research (SAR) in Sante Fe, "The Mosquito" at the British Academy, "Agrarian Studies, Climate Change, and the Future of Work" at Cornell University, "Planetary Health" at the Berggruen Institute, "Tech Life Lab Seminars" hosted by the School of Geography and the Environment at Oxford, the Anthropology Colloquium at the University of Pennsylvania, and the Science and Society Research Seminar at the University of New South Wales in Sydney. Much of the early thinking around entomological work and labor was encouraged and fostered by the brilliant colleagues who formed the Anthropologies of African Biosciences group at the London School of Hygiene and Tropical Medicine. A year at Princeton University's Institute of Advanced Study allowed us to sharpen our argument with the help of the brilliant colleagues whom we met while we were there. The Princeton Multispecies Salon, convened by Augustín Fuentes,

was a multidisciplinary oasis that pushed us to account for ecological terms we had taken for granted.

Finally, we are hugely thankful João Biehl and Vincanne Adams for their faith in the project and to Ken Wissoker, Elizabeth Ault, and Kate Mullen, and the remarkable editorial team at Duke University Press for their patience and care in bringing it out to the world. We were unbelievably lucky in our two reviewers, who helped us chip a recognizable argument from the massive stone block dropped in their inbox. The depth of their critical engagement helped us to better articulate our intellectual commitments and their implications. We hope they can see their hand in our case for a "more hopeful" global health.

As much as it owes to these formal conversations, ultimately the book is the product of enduring intellectual companionship. Tim Allen, Nikhil Anand, Andrew Barry, Uli Beisel, Sarah Besky, Carlo Caduff, Nerea Calvillo, Clare Chandler, Alberto Corsín-Jimenez, Jamie Cross, Will Davies, Mike Degani, Sarah Dry, Pedro Ferreira, Dev Gangjee, Beth Greenhough, Marty Gross, Vanessa Grotti, Michael Guggenheim, Clare Herrick, Steve Hinchliffe, Frédéric Keck, Chris Kelty, Monika Krause, Andy Lakoff, Hannah Landecker, Guillaume Lachenal, Jamie Lorimer, Ilana Löwy, Christos Lynteris, Manjari Mahajan, John Manton, Noortje Marres, Ramah McKay, Ella McPherson, Fabian Muniesa, Alex Nading, Bronwyn Parry, Melissa Parker, Branwyn Poleykett, David Reubi, Lina Pinto García, Joan Richardson, Emilia Sanabria, Nikita Sud, Alice Street, Noémi Tousignant, Sonja Van Wichelen, and Gisa Weszkalnys—without the care and company of these chosen kin, the "life of the mind" would be a slight existence indeed.

Finally, we thank our families in Bilbao and New York, who created the conditions for the ideas that preoccupy the pages that follow, cultivated our interests, and gave our passions direction. William Kelly, a true pragmatist—in the best possible sense of the word—read the entire manuscript in its draft form and gently helped us anchor our most exuberant flights of thought. Bridget Lyons's fearsome faith in the project kept us going when our enthusiasm flagged, and with great sadness we finished this project when she was not here to see to its end. Our brilliant *chicos*, Oskar and Imanol, taught us again how to wonder and what a powerful tool it can be with which to navigate the world. Without their cheerful nudges—"Is that mosquito book finished yet?"—we fear *Mosquito Work* would have remained forever lost somewhere on Dropbox. It is to them this book is dedicated, a song of praise for those who draw our attention to the persistent and tiny in the expectation of a better future.

Introduction

On August 14, 1881, Carlos Juan Finlay, a Cuban ophthalmologist with an abiding interest in public health, presented his views on yellow fever to the Royal Academy of Medical, Physical and Natural Sciences in Havana. The focus of his report was not the *cause* of the disease—"the nature or form in which the morbigenous factor in yellow fever exists," as he put it—but rather its spread: "the medium or agent by which the pathogenic material of yellow fever is carried from the bodies of the infected to be implanted in the bodies of the non-infected." Yellow fever, Finlay surmised, was not contagious, but it was *portable*. The "medium or agent" of carriage was the mosquito.[1]

Finlay's theory of contagion was fairly heretical at the time—although the Scottish physician Patrick Manson was then advancing an argument for the role of the mosquito in the spread of another tropical disease: lymphatic filariasis.[2] The timing and geographical distribution of Cuba's rolling yellow fever epidemics, which had been bringing untold death to the island for more than two centuries, dovetailed with the abundance and dispersion of the mosquito population. Drawing from extensive observations of mosquito biology, ecology, and behavior, Finlay tried to put his hypothesis beyond doubt by having mosquitoes feed on the blood of yellow fever patients and then allowing them to bite soldiers recently arrived from Spain. It was Finlay's hope that these laboratory experiments, combined with impeccable epidemiological reasoning, would be compelling enough evidence to convince his esteemed colleagues. It was not. Derided as an entomological zealot with a penchant for rogue experimentation, Finlay's repeated calls to fumigate houses and eliminate mosquito breeding grounds fell on deaf ears. It would take twenty years before the rest of the world caught up with the "crazy Cuban doctor."[3]

In the meantime, investigations by Charles Laveran, Ronald Ross, Giovanni Grassi, and several others were advancing a similar "mosquito theory" to explain another age-old fever: malaria. With the discovery of malarial pathogens in humans, birds, and mosquitoes, researchers began to elucidate the complex interspecies dynamics involved in the transmission of this disease. Over time, human malaria would be revealed as caused by parasites of the *Plasmodium* genus, highly adaptive unicellular protozoa whose life cycle unfolds across two organisms: a vertebrate, in which the parasite initiates its sexual development, and an *Anopheles* mosquito, where it reproduces sexually and evolves into a form capable of transmission to a new vertebrate host.

Considering the mosquito as a *vector* of these diseases—the infectious medium, agent, or carrier of civilization-shaping maladies—opened up entirely new vistas for expert knowledge and practical action. Diseases that had been attributed to miasmatic conditions, climatic patterns, or ill-understood forms of contagion could now be prevented, perhaps even altogether purged, by thwarting the wispy but fateful encounter of human and mosquito. Whether the pathogen in question was a malarial parasite or the arbovirus responsible for yellow fever or dengue, the mosquito offered a conspicuous target for attempts to suppress transmission and protect human settlement.[4]

A catalyst for the consolidation of public health as discipline, the fight against mosquitoes became a central thread in the history of modern medicine, giving the *sciences of the vector* a constitutive role in the formation, expansion, and dismantling of empires.[5] In the early twentieth century, programs of mosquito surveillance and habitat destruction often defined the reach of imperial enterprises, providing a medico-military brand of "control" organized around the interests of new commercial endeavors and settler economies. More often than not, the effort to sanitize landscapes and protect populations against the threat of vector-borne viruses or parasites was addressing the direct pathogenic effect of colonial expansion: the intensification of mosquito reproduction and disease transmission that followed trade, deforestation, large concentrations of native labor in new industrial enterprises, or the rapid growth of urban settlements where a vast majority of residents lacked basic sanitation.[6]

Campaigns against yellow fever in Havana, Rio de Janeiro, or Hong Kong advertised themselves as "civilizational" enterprises, intent on making fast-growing metropolises hospitable to white Europeans with no natural immunity to tropical diseases. In the emerging archipelagos of intensified colonial exploitation, from tea plantations in northern Bengal to mining towns across the central African copper belt, malaria control was justified as a means of sustaining the productivity of extractive enterprises along new capitalist frontiers. Many of the

engineering projects that rendered the world available for new cycles of capitalist accumulation—from the opening of the Panama Canal to the construction of the Aswan Dam or the draining of the mangrove swamps in Lagos—were key trials of strength for mosquito control.[7]

The very focus on the *vector* gave the game away, for it signaled a fundamental preoccupation with territorial expansion—the ever-widening circulation of people and things in space. Treating malaria or yellow fever in their clinical manifestation, as disease afflicting human bodies, was a Sisyphean task if the environment remained "infested" with insect carriers of disease. By contrast, eradicating or at least suppressing the relevant vector would bring about a wholesale reconfiguration of that environment, liberating vast swaths of land for economic exploitation and settlement. This is why mosquito control typically functioned as a *frontier* enterprise, a practice of pushing out the edges of Euro-American civilization, whether this was along new agricultural homesteads or in the fast-growing slums around centers of colonial administration.[8]

Medical entomology was forged in these colonial encounters and bears to this day the traces of its imperial origins. Yet the stories it encompasses are inevitably complex and point in a variety of directions. In many instances, entomological research and vector control programs gave rise to ambivalent and even subversive forms of exchange. The practical activities of knowing and acting on mosquitoes often recapitulated Indigenous ecological understandings and sanitary know-how in an exercise of translation that was invariably parasitic and often purely extractive. As Clapperton Chakanetsa Mavhunga shows in his history of the fight against *mhesvi* (the *Glossina* or tsetse fly of European entomology) during the period of white rule in Zimbabwe, European disease control agents expropriated vernacular knowledges of disease ecology to better subjugate not just the insect vector but the Indigenous population on whose energies the project of European settlement relied.[9] Rohan Deb Roy tracks a similar set of "entomo-politics" at play in the British efforts to eradicate white ants in South Asia, one of the more troublesome "tribes on the frontier" and a species whose appetites for wood and paper—material foundations of the colonial state—became a metonym for native recalcitrance to rule.[10]

In other instances, extensive field studies and long-term research pursuits provided the context for unlikely collaborations between local and expatriate researchers. Occasioned by the limitations of colonial administrations and their sheer ignorance of the landscapes they sought to control, these collusions made room for collaborative knowledge exchanges, inspiring modes of inquiry that sometimes subverted received scientific convention and gave rise to new conceptions of the social reality of disease, its ecological causes, and viable techniques

of intervention. Even in classic "research enclaves" thoroughly self-isolated from the medical needs of the surrounding population, the interaction of expatriate Euro-American researchers and local technicians and laborers seeded ways of knowing that could eventually gain local public health relevance. In her account of the Bwamba station in Uganda, Julia Cummiskey describes the extensive fieldwork and trapping innovations of African assistants, who helped to elucidate the forest circulation of the yellow fever virus as well as transform the role of the field laboratory into a site for place-based experimentation.[11]

Decolonization and postcolonial nation-building led to a new institutional landscape of entomological research and vector control efforts. Latin America was the first region to experiment with the formulation of *national* approaches to the fight against mosquito-borne diseases. In Brazil, advanced programs in malariology and yellow fever control during the First Republic (1889–1930) were key components in the country's drive toward "modernization" and in the expansion of its internal frontiers. What emerged here, as elsewhere in the continent, was a specifically national and often nationalist vernacular of "tropical medicine," distinct in scope and orientation from the sort of territorially and socially circumscribed interventions that characterized the work of colonial administrators at the time.[12]

Cuba offers another illustrative example. At the turn of the twentieth century, during the first period of US occupation, the island became the testing ground for new methods to combat yellow fever through large-scale mosquito abatement. But it was only after the country gained its independence and was able to pursue its own public health priorities that Carlos Juan Finlay became a national hero.[13] These pioneering efforts by newly independent states contributed to, and benefited from, new regional initiatives. The Pan American Sanitary Bureau—the first international organization to formally endorse the "mosquito theory" of yellow fever (at its inaugural conference in 1902)—offered a model of inter*national* collaboration long before the League of Nations (or, later, the World Health Organization or WHO) placed the fight against mosquito-borne diseases at the top of their agendas.

Comparable processes of decolonization would unfold in the mid-twentieth century in many Asian and African countries. Often, the cadres of local technicians through whose (invisibilized) labor and expertise the "British," "French," or "Portuguese" schools of medical entomology had been established became the architects of the public health systems of newly independent states. This dynamic institutional landscape emerged through, but also in spite of, the connections created through the networks of imperial vector control.[14] As Sunil Amrith notes with respect to South and Southeast Asia, "the relationship between

colonial public health and post-colonial internationalized public health was complex and unpredictable," adopting different complexions in different countries depending on the aspirations and capabilities of the state in question.[15]

As a result of these political transformations, in the middle of the twentieth century mosquito control became a paradigmatic international enterprise. This internationalization relied heavily on technologies developed during World War II, most crucially DDT (dichloro-diphenyl-trichloroethane). Only by virtue of the spectacular lethal power of this and other organochloride chemicals were the international mosquito elimination efforts pursued by WHO against *Anopheles* or by the Pan American Health Organization against *Aedes* even conceivable.[16]

By the late 1960s, however, any prospect of gaining a definitive victory against mosquitoes had been lain aside. The failure has multiple roots, many of which run across the stories told in this book, but they can all be traced back to unanticipated feedback loops between standardized chemical tools, anthropogenic pressures, and changing political realities. Population growth, rapid urbanization, and the reconfiguration of landscapes for intensified economic exploitation created a new world in which chemical control through organochlorides quickly lost its footing. The expansion of industrial agriculture was a particularly crucial factor in the case of malaria: the Green Revolution created large new habitats for *Anopheles* mosquitoes while the mass use of chemicals for agricultural pest control blunted the efficacy of DDT. The *Aedes* mosquitoes responsible for the transmission of yellow fever, dengue, and other arboviruses proliferated alongside rapidly sprawling networks of international travel and trade. Disease vectors successfully adapted to human ingenuity, neutralized all manner of chemical attacks, and used the many gaps and interstices in state capacity to find new niches in which to breed and thrive. By the end of the Cold War, malaria was on the rise across most of sub-Saharan Africa and Southeast Asia, yellow fever was expanding across Africa and the Americas, and dengue was becoming entrenched in the fast-growing cities of the tropics.[17] Among vector-borne diseases, malaria was by far the biggest killer. In 2000, WHO estimated 262 million cases of malaria and 839,000 deaths attributable to the disease (the vast majority children under five).[18]

The new configuration of science, politics, and disease that would come to be known as "global health" emerged at this particular historical juncture, during a period of uncontested US hegemony. A new campaign to eradicate malaria was launched in 2007, this time not under the auspices of an international organization or a powerful state but at the behest of the Gates Foundation, a philanthropic actor with global reach and aspirations. New funding streams opened up for dengue and yellow fever research, and a host of novel

technologies for the control of *Anopheles* and *Aedes* mosquitoes began the long transition from the laboratory to the field.

We will formulate our approach to the institutional realities of "global health" later in this introduction, but it is important to insist here on the importance of placing this recent—and arguably now concluding—chapter in the configuration of transnational health problems within the longer trajectory of human efforts to understand mosquitoes and their capabilities as vectors of disease. The accounts we provide in this book will stray frequently into the archives to illuminate the genealogy of contemporary understandings and predicaments. A degree of historical awareness is not offered here as a means of avoiding past mistakes, even less so as a justification for being pessimistic or cynical about endeavors yet to come. It is tempting to see entomological research and vector control as reprising a set of ever-returning themes—the rise and fall of different versions of insecticidal utopianism, for example—but this is one of those cases where history does not quite repeat itself, even when it rhymes. The essential value of attending to the longue durée of the mosquito-as-public-health-problem is that it allows us to observe how scientific knowledge and the forms of practical action it authorizes have evolved over long periods of time and across diverse institutional arrangements—and to imagine different ways of articulating this nexus of knowledge and action in the future.

Within that long seam of mosquito work, there are myriad stories to mine and tell, accounts grounded in the mundane but momentous practices of observing mosquitoes, learning about their predispositions, and applying that hard-earned expertise to the prevention of disease. These painstaking labors, often conducted with little hope of enduring success, entangle global health action in the material specificities and micropolitical realities of its many and disparate locations; universalist aspirations are, by necessity, tethered to concrete people and places, and they are often undermined, sometimes enhanced, and always mediated by the specificity of local lives and livelihoods. Our contention is that, examined in a long historical perspective and with due attention to the always shifting local ecologies of knowing and doing, the practices of vector control will allow us to plot alternative futures for global health.

Restless Inquiry, Wild Facts

In formulating the core ideas for this book, we have drawn inspiration from scholars working across various fields, subject areas, and theoretical frameworks—an eclectic and ranging approach to "the literature" that has taken us from political philosophy and medical anthropology to the environmental humanities and the

history of art. While lacking clear disciplinary orientation, our line of enquiry follows from a preoccupation with how the mosquito is made knowable and what forms of action ensue (and which ones do not) from that knowledge.

This critical bearing has been inspired and nurtured by various engagements with pragmatism. A not-quite-philosophical standpoint that privileges practice over principles, embodied experience over metaphysics, pragmatism is concerned with the calibration of human action in a universe that is, in William James's famous phrase, "pluralistic" and "restless."[19] A pluralistic universe—or pluriverse—is a world made up of phenomena, connections, and relations not reducible to any single principle or perspective. Its multiple and heterogeneous parts might still be "conjoined by knowledge," but that knowledge never reaches a point of absolute unification; it is rather "strung along and overlapped," compatible with the hypothesis "of a world imperfectly unified still, and perhaps always to remain so."[20] Restlessness describes the dynamic quality of that universe, the fact that its multiple agencies are not arranged in any sort of equilibrium or balance, and push it in the direction of further self-differentiation.

If the universe is very much in the making, as James suggests, and this making is contingent and in flux, any investigation must start from the position of social actors confronting concrete problems—actors always forced to make consequential decisions in light of new experiences. Action, in this register, is not only flexible and adaptive but also ontologically creative: Our deeds and conduct establish the connections (technical, institutional, ideational) that make our "blooming, buzzing confusions" coalesce. "Our own reactions on the world," writes James, "small as they are in bulk, are integral parts of the whole thing, and necessarily help to determine the definition [of the world]."[21]

The privilege it grants to experience and the existential priority it bestows on human agency render pragmatism particularly congenial to the sciences. Its antifoundational stance—what Cornel West called pragmatism's "evasion of philosophy"—is fully compatible with, indeed demands, faith in the scientific enterprise.[22] In this light, science is not the source of final or incontrovertible truths but a practice of inquiry oriented toward an ever-growing appreciation of the world and its "wild" facts—those observations that do not fit preexisting schemes or accepted wisdoms, often because they arise from our very actions on nature. Seen from this perspective, science is an engine to appreciate the infinitesimal complexity and inherent reactivity of the universe, a *vector of thought* that triggers endless adjustments in our discernment and comportment.[23]

Science is, above all, a collective endeavor. It is a manifestation not just of individual ingenuity but of the reach of a certain "community of inquiry," to borrow Charles Sanders Peirce's phrase.[24] The communitarian essence of science

pertains not only to its epistemological criteria of truth—how do we decide that we know what we know?—but to its capacity to make that knowledge an instrument of change, to implicate the process of inquiry into "the very fabrication of the world."[25] A "community of inquiry" encompasses not just the scientists and researchers investigating a certain phenomenon but all those who have a stake in addressing the issue at hand. For without tethering those investigations to salient "matters of concern," knowledge remains merely *representational*, inert facts incapable of creating the capabilities needed to respond to the demands of the world we live in. A community of inquiry is the precondition for realizing the full potential of knowledge *as* action, for transforming representations into consequential decisions.[26]

Medical entomology offers a compelling domain for this sort of pragmatist approach. The great midcentury naturalist Marston Bates observed in his entomological masterpiece *The Natural History of Mosquitoes* (1949) that our knowledge of disease vectors is constrained by our abiding lethal intent. "Much that has been written about mosquitoes," he noted, "is concerned directly with methods of killing them." As a consequence, he argued, the mosquito as a "living animal" had fallen into a glaring blind spot. The typical student of biology, Bates pointed out, "views mosquitoes as something to be swatted, rather than as potential sources of information about the biological processes that govern the bewildering organic world that we inhabit."[27]

Killing remains the dominant preoccupation in determining which knowledge of mosquitoes is relevant. Today, three quarters of a century after Bates penned his observation, any knowledge generated in order to better kill mosquitoes must contend, first and foremost, with the consequences of failed attempts to do so in the past. For the mosquito as "living animal" is always living in an *aftermath*—that is, in the wake of repeated efforts to suppress the species. Entomologists and vector biologists tend to make sense of this situation through the language of "resistance": mosquitoes grow progressively inured to the methods (particularly chemical) we deploy against them. Yet "resistance" is a misleading term. It tends to be interpreted as an extrinsic "material and social recalcitrance," Steven Hinchliffe argues, and thus as "a matter to be overcome." Yet resistance is better seen as "an integral part of social power" and thus as "an event that ushers in new possibilities, and new modes of normativity."[28] To put it in even more Jamesian terms, resistance is an expression of the restlessness that defines the universe.

Existing in the aftermath of prior and current attempts to suppress them, *Anopheles* and *Aedes* mosquitoes exemplify the condition that ensues from human attempts to conquer nature, what Hannah Landecker describes as

"anthropogenic biology": a patterning of life that is specific to each form of control but is indecipherable from within the logic that animated those efforts in the first place.[29] What defines the mosquito's restless mode of existence is not stubbornness, or even adaptation to an exterior force, but the sort of "feral proliferations" that follow from the oversimplifications that we (humans) tend to impose on landscapes and ecosystems.[30]

Medical entomology, is in other words, represents a set of scientific practices always reacting to the consequences of the forms of control it authorizes, a knowledge formation as concerned with any "natural" liveliness of mosquitoes as with the unintended effects of our long-standing attempts to eliminate them. Successful vector control thus demands a constant recalibration of action in relation to past efforts and in appreciation of the transformative effects of any hoped-for success. This is where pragmatism can fulfill its promise as a "radical art of consequences," and why criticism that reduces it to mere *instrumentalism* misses the mark.[31] Far from implying a wholesale defense of "whatever works," pragmatism brings intense scrutiny to bear on the question of what *working* means. When can a particular approach be deemed "workable," and what may be the consequences of that "working"? For any successful instrumental operation—any achievement, however partial, in subjecting natural agencies to our designs—changes the parameters of knowledge- and world-making, setting in motion a new sequence of events that alters the initial conditions of possibility.

Finally, pragmatism offers us valuable resources to understand the contingent, creative nature of the *publics* that emerge in response to complex problems. Pragmatism teaches us that publics coalesce when individuals perceive themselves to be affected by an issue and decide to care systematically for its consequences.[32] Those collective and passionate investments cut across preexisting communities, implicating strangers in new social orders as they seek to respond to a current state of affairs. Publics "adopt problems that no one is taking care of," as Noortje Marres puts it, "because if the public doesn't adopt the issue, no one will."[33]

When successful, mosquito control is always a public-making enterprise, often explicitly so. It requires the enrollment of a range of material agencies and the dedication of heterogeneous collectives—researchers and technicians, yes, but also different kinds of "volunteers," local officials, funders, nongovernmental organizations, and countless other actors active in the areas where a particular intervention is deployed. Very often those publics are fairly rigid and monotonous: Residents are asked to perform a set of repetitive duties to keep mosquitoes at bay or to adopt a new technology that promises to change their lives for the better. These "partial"—or more precisely, *non*-recursive publics, to adapt Christopher Kelty's term, are tasked with implementing an externally imposed

solution, without tackling the underlying and locally salient conditions that brought their members together in the first place.[34]

In some rare and precious cases, however, these publics become more comprehensive in their concerns and responsibilities. Removing disease-carrying mosquitoes from a given area demands attention to a sprawling set of questions of material politics, including the pattern in which water accumulates after rainfall, the gendered labor invested in routine acts of domestic upkeep, or the sedimentation of past chemical action that triggers the emergence of mosquito "resistance." A disease vector is an agent of connection—not only between different life forms but across the multitude of agencies that impinge upon the transmissibility of a certain pathogen. Mosquito control may imply a particular "art of noticing"[35] or "art of attentiveness,"[36] but the most interesting quality of this noticing or attending is that it cannot remain trained solely on the mosquito. Issues proliferate and get entangled in one another because they trace the trajectory of an actor—the mosquito, the *vector*—that insinuates itself into crevices of the everyday and makes explicit new relations and agencies that command attention.

Pragmatism helps us appreciate the situational nature of these *vector publics*, the contingent manner in which a transformative collective can emerge when the problem of mosquito control becomes connected to matters of infrastructural provision, toxic exposure, and other long legacies of material neglect. It provides a lexicon to rearticulate these problems, implicating new sets of actors, spatial arrangements, and temporal horizons to generate more robust public health interventions. It is, furthermore, a critical grammar that has helped us foster a more meaningful dialogue with our entomological colleagues, putting our distinct empirical projects into conversation and at the service of a more cosmopolitical aspiration.[37]

Global Health

These are the reasons that have driven us to apply or rather "relay" a pragmatist sensibility to the study of global health through the lens of medical entomology and mosquito control.[38] By *global health* we mean the set of institutionalized practices and forms of knowledge that emerged at the turn of the twenty-first century to tackle transnational health problems deemed to affect populations in situations of dire and structural need. This vision crystallized during a period of increasing global trade, human mobility, and economic deregulation, and the actors who formulated it did not need to think too hard about what constituted a properly "global" problem or a concomitantly global "solution." In contrast

to the Cold War regime of international public health, which was constantly preoccupied by the politics of projecting problem definitions and potential fixes across ideological divides, global health defined the scope of its ambition by reference to the self-evident value of its humanitarian intentions. In this respect, its geographic imagination always evinced a certain *frontierism*: It was an enterprise oriented toward the problems that fester on the edges of settled life and domesticated environments. This liminal quality was crucial to the endeavor because, as Betsey Brada argues, "the imaginative project of the global health frontier legitimates a potentially endless horizon of intervention."[39]

Global health tended to start from a position of radical *dislocation*: The scientific knowledge and technical tools that underpin its programs were generally produced far away from their contexts of use, in institutional spaces distant—geographically and existentially—from those of the actors expected to benefit from their application. Global health came to mean a set of "interventions into the lives of *other* peoples," to use Randall Packard's pithy phrase.[40] In this arrangement, there is no self-evident or preexisting "community of inquiry," and much global health work is consequently focused on linking up far-flung and disparate spaces of agency, on creating, sometimes from scratch, practical and moral connections between science and the constituencies it is meant to serve. (As we ourselves know all too well, this predicament creates a propitious opening for the ultimate interloper: the social scientist tasked with intermediating divergent "social" worlds.)

Often this attempt to bridge distance and difference fails, or frays and unravels quickly, and we are left with a lofty piece of evidence or a well-meaning product that never touches ground in public health realities. The result is what we might call "surplus science": elegant facts and technologies produced in excess of what the social actors confronting the problem in question can effectively put to use.

The difficulty in articulating knowledge and action when problems and solutions emerge from different spaces of experience lies at the root of one of global health's most characteristic biases: its preference for *scalable* fixes: programs that can be implemented without significant alteration across diverse territories and populations. Scalability describes, in Anna Tsing's terms, "the technical feat of creating expansion without the distortion of changing relations."[41] It is the ideal of diffusion without adjustment—an axiomatic geometry that is central to how global health institutions understand the "global" nature of their ambitions. They see their mission as tackling problems that by definition exceed the capabilities of actors on the ground, and that require "solutions" that can be deployed effectively across heterogeneous contexts with minimal accommodations to local circumstances.

Driven by a commitment to coverage that is at once universal and generic, these global health "solutions" tend to take the form of *commodities*. Whether it is a chemical compound, a rapid diagnostic, or a novel bed net design, it is the circulation of a standardized physical object—its "distribution," "deployment," or "rollout"—that helps alleviate the problem in question. Need is thus recast as a matter of *access* to finished products, and philanthropic impulses are fulfilled through acts of delivery.

A "global" scope of action is thus tied to a decidedly narrow vision of the *instrumental*. Whether it advances a humanitarian agenda centered on "neglected" diseases and populations, or pursues a biosecurity preoccupation with "emerging" pathogens, the global health enterprise relies typically on the circulation of "life technologies": prepackaged goods that have been conceived, developed, and more often than not manufactured far from the contexts where the problem in question is most pressing.[42] Global health thus approaches the "field" of its own endeavors from a *distal* position: It is either a site for the extraction of facts—as in the many research stations and experimental populations where global health evidence is generated—or the unwieldy territory of "deployment," where uneven and unpredictable local conditions often frustrate the smooth *placement* of solutions. Lost in the process are the positive presences—the endogenous capabilities and instrumentalities—of each locale, the ways in which the field, more broadly construed, can be generative of unique insights and modes of action.

In relation to mosquito-borne diseases, the long-lasting insecticide-treated net (LLIN) offers a particularly salient example of these dynamics. Over the last two decades, the mass distribution of this commodity has led to significant reductions in malaria mortality and morbidity in many countries, particularly in sub-Saharan Africa. The specific affordances and limitations of this product feature in many of our chapters, but our point here is that the LLIN synthesized a variety of protective effects into a singular humanitarian good, at the cost, as Uli Beisel has shown, of disentangling it from local economies of production and reuse.[43] So today, more than two decades after their public health value was conclusively demonstrated, the vast majority of the LLINs used in Africa—where more than 90 percent of malaria deaths are recorded—are still manufactured outside the continent, and the supply of this essential commodity continues to be at the mercy of funding from foreign donors.

This attempt to reach universal coverage through the dissemination of commodities often results in a sort of "chimeric globalism," as Alex Nading calls it, which reduces the diverse public health realities created by a new technology into a bottom-line tally of "lives saved" per dollar spent.[44] As Jamie Cross and Alice Street suggest, this approach combines a "minimalist" ethic of care with a

"maximalist," indeed utopian, aspiration to use technical objects as "the building blocks for new kinds of universal infrastructures that are delivered through the market."[45]

When it comes to dealing with mosquitoes and the diseases they carry, the limitations of this global health imaginary are all too apparent. If we take seriously the mosquito as *vector*, a "medium or agent" of pathogenic connection, we quickly realize that what is at stake is much more than killing or suppressing a noxious organism. The problem indeed reaches deeply into the configuration of daily life and the distinct distributions of risk and exposure that emerge from man-made environments shaped by the legacies of past interventions. Mosquitoes are "archives of contamination": They index, in their genomes and behavioral dispositions, the myriad anthropogenic dimensions of their milieu and the effects of multiple attempts to kill them.[46] What a technology of vector control must master is not so much the intractable vivaciousness of mosquitoes as it is the feral qualities of life in a pervasively industrialized world.

Our inquiry must thus set off from the field, but a field considered in all its restless potential. We must begin among the potholes and tire wells and coconut shells where mosquitoes breed and alongside those who are working to bring their transient and ever-imminent presence into clearer view. It must proceed from an appreciation of the immensity of the task—not as it is rendered by sophisticated metrical aggregations and scalar operations, or the self-evidence of lives "in crisis," but arrived at by experience, from the work of responding to the problems mosquitoes pose to life lived in the everyday.

A Field Guide

We have tried to imagine this book as a sort of field guide, modeled after the vector ecology manuals and mosquito abatement primers that take pride of place on our collaborators' shelves. Field guides cut across two domains of practice. Small and cheap, these are books meant for the amateur naturalist—to be popped in a rucksack or slid into a pocket by anyone who takes pleasure in knowing better the world around them. Field guides provide points of orientation, visual references, aural cues, classification keys, and thick descriptions to cultivate an immersive attention, retraining the reader's lines of sight, art of listening, pace of footfall.[47]

But field guides are also protocols for intervention. They are a practical resource for the nonspecialist to diagnose problems and develop strategies to respond to them. Among the most important of WHO's technical contributions,

their series of field guides—whether focused on implementing a vaccine campaign, containing an Ebola outbreak, or improving the safety of drinking water—offer a means of *doing* global health across a variety of ecological, economic, and political situations.

As both a tool to cultivate a naturalist's attention and a protocol for practical intervention, the field guide formulates mosquitoes as workable problems for those sufficiently proximate to fully apprehend their dynamism. The idea of "the field" that emerges from such a manual is hopefully different from those that dominate global health interventions—a circumscribed site for the production of evidence or the chaotic context of implementation. In this field guide, the field is rather a tool to create continuity through contiguity, an imaginatively habitable surround.

Each chapter takes inspiration from an entomological art or practice. The first, "Collect," zeroes in on the contraptions that enable researchers to capture mosquitoes in the wild and start the process of immersing themselves in their infinitesimally complex world. Touring a strange gallery of trapping boxes, suction tubes, wind tunnels, and experimental huts, we will observe how those contrivances not only bring vector biologists into contact with mosquito bodies but also infuse disease control with a sense of place and a command of contingency. Pursuing the concept of the *makeshift*, the chapter analyzes the multiple genres of emplacement deployed in the practice of mosquito sampling and how public health realities are projected from aggregations of tiny insect bodies collected in mesh boxes and Styrofoam cups.

The second chapter, "Dissect," explores another foundational art in medical entomology: the dexterous teasing out of mosquito bodies, the practice of pulling organs and tissues apart in order to extract epidemiologically relevant information from individual specimens. We focus here on the story of the Polovodova method, an exquisite Soviet dissection technique used to determine the physiological age of a female mosquito by detecting dilatations in its ovarioles. By exploring the unsuccessful attempt to export this technique to Africa to assist in malaria eradication efforts there, our account fleshes out a theme that cuts across the book as a whole: how what counts as useful knowledge is determined by the form of control being pursued. Instrumental to campaigns of malaria elimination in the Soviet Union, where it was widely used to assess the "vectorial capacity" of mosquito populations, the Polovodova method became an "esoteric" skill—an overly exacting technique yielding a surplus of impractical knowledge—amid the blunt realities of large-scale, uniformly-delivered chemical spraying.

Taken together, these first two chapters consider the forms of investigative intimacy afforded by the *handling* of mosquitoes. They suggest that the sensory habits and intense "bodywork" attendant to collecting and dissecting sustain the attunement of medical entomologists to the bionomic flexibility of mosquitoes.[48] They also reveal how this attunement is embedded in associations of heterogeneous actors. Discerning patterns of contagion from aggregations of mosquito wings, guts, and proboscises depends on a vast cadre of workers—technicians, research subjects, remunerated laborers, and project volunteers—entomological collectives whose expertise is as much a measure of technical proficiency as a feature of their creative ingenuity.

Chapter 3, "Rear," explores the adaptation of mosquitoes to life in scientific captivity and the use of laboratory-reared mosquitoes as a weapon against their wild counterparts. The possibility of transforming a vector of disease into an instrument for its control is the promise of many recent innovations—from gene drives to infection with *Wolbachia* bacteria. We focus here on past attempts to instrumentalize the vector through programs of mass mosquito sterilization and release. We describe in detail an early apotheosis of this approach: the trials carried out in El Salvador in the 1970s, when the ability of sterilized *Anopheles* males to suppress mosquito reproduction was assessed in one of the most malarious regions in the world. The culmination of a long tradition of government-funded entomology in the United States, the trials in El Salvador brought face to face the two key avatars of industrial entomology: the mass-produced, chemically sterilized male and the recalcitrant, chemical-tolerant female. Their clash defined the limits of technologies of mosquito modification in a world radically transformed by the toxic legacies of capitalist agriculture.

Chapter 4, "Repel," considers an alternative to the deployment of lethal chemical force: the use of irritants to divert mosquitoes away from their human targets. We explore in particular the affordances of *spatial* repellents, products designed to create protective atmospheres around particular "spaces of concern." In the history of public health action against mosquitoes, spatial repellents represent a rather heterodox approach. It is a *sublethal* strategy oriented toward peridomestic sites and interactions, difficult to reconcile with the insecticidal, house-bound logics that have dominated malaria prevention since the mosquito was identified as the vector of the disease. The chapter follows attempts to standardize and evaluate spatial repellent products in Tanzania's Kilombero Valley, where different forms of "resistance" by *Anopheles* mosquitoes are driving a search for new formats of protection against malaria. Spatial repellents raise a series of evidentiary and ethical challenges, but they also allow us to imagine

alternative approaches to disease prevention, focused on the spatial and temporal in-betweens of social life.

In conjunction, chapters 3 and 4 shed light on the multiple varieties and valences of chemical action against mosquitoes. For more than a century, our repertoire of options for vector control has been essentially chemical, but "chemical" encompasses a wide variety of modes of action and is compatible with diverse intensities and topologies of application. The stories we tell in these two chapters encompass lethal and sublethal, high-tech and low-tech approaches, each expressing a different immunitary iimagination—from an all-out chemical war of mosquito extermination to the deployment of irritation to create situated "bubbles of protection."

The final two chapters of the book tackle the question of vector publics: what sorts of collectives can emerge through the attempt to tackle mosquitoes and the diseases they transmit. Chapter 5, "Release," takes as its starting point the long tradition of "community engagement" against mosquitoes in Rio de Janeiro. The introduction in 2014 of *Wolbachia*-infected *Aedes aegypti* as a potential new tool to suppress the transmission of dengue and other endemic arboviruses brought with it innovations in public outreach practices that sought to transform the liberation of modified mosquitoes into an opportunity for public dialogue, at a time of multiple and converging crises of urban governance. By elaborating on the role and experience of the engagement expert, the individual tasked with the burden of fostering public dialogue, we gain a different vantage point on the question of which forms of civic transformation are possible in the context of an experimental intervention—and which ones ultimately are not.

Finally, Chapter 6, "Swarm," describes the twilight assemblies of mosquitoes and their mating rituals as a site for the creation of new entomological collectives. *Anopheline* swarms are an enigmatic, poorly understood, rather opaque phenomenon, but in recent years they have attracted the attention of entomologists in different African countries as a potential target for malaria control efforts. "Swarm killing" was first pioneered in Burkina Faso, where researchers developed detailed expertise on the spatiotemporal coordinates that structure mosquito gatherings. The chapter describes the transfer of swarm targeting expertise to Tanzania's Kilombero Valley. The training of swarm searchers and their eventual success underscore all that is involved in transposing "community-based" interventions from one place to another. The reluctance of international funding and regulatory bodies to endorse an approach seen as too "local" to meet their criteria of "scalability" helps us understand the limits of the global health enterprise as currently configured. At the same time, the story of the Kilombero swarm searchers illuminates what is at stake in

producing a form of vector control that is proportionate to the specific publics it seeks to protect.

Across the book, we attend to the personal biographies and sociomaterial circulations of mosquito research—the minor gestures, technical improvisations, and proto-political innovations that often fall out of the canon of global health "solutions." Much of the work we detail in the pages that follow did not yield any "big" results, let alone any final settlement to the pathogenic entanglements of humans and mosquitoes. Our stories are full of control programs that failed to control, skills never fully translated into technique, and experiments that ended up casting doubt on their own assumptions. And yet granular attention to the strenuous life of entomological research and mosquito control remains, we believe, a source of inspiration. For these always-partial accomplishments, secured against daunting odds and in full view of the complexity of the challenge, offer a guide for how to act/collaborate in a world that is unfinished and responsive to human efforts. This is why we introduce some recurrent key characters—researchers who have been our colleagues, friends, and interlocutors during almost two decades of work. They exemplify, we believe, the ethos of entomological endurance the book hopes to celebrate; they are living examples of the possibility of making global health *workable*.

As an (appreciative) anatomy of hard-won practice, the book also underscores what, to our mind, is the central contribution of pragmatism to our project. Rather than a frontier of continual and ever-widening intervention, global health can be a site to animate and provoke new collectives that are, in Savransky's words, "capable of mediating the world according to their own departments, for their own reasons, with their own criteria, and in relation to their own concerns."[49] Those concerns are not necessarily bound to a particular geographical place; they often express a form of collective care that may, indeed, be global in reach. What sets this approach apart from the traditional transfer or roll out of a global health solution, however, is the degree to which expanding the scope of interests can realize the capacities of a greater diversity of individuals and cultivate a social intelligence that is as broad as it is deep.

The cosmopolitical possibilities of amplifying those commitments is where our argument will reach its conclusion. Our concluding chapter examines the contemporary imagination of "a world without mosquitoes" and the kind of cruel optimism that arises from promises of ceaseless progress and enduring visions of a future without disease.[50] The tiny bodies of mosquitoes magnify our collective discomfort with the natural world; their bites, as inexorable as they are commonplace, pierce any conceit of human control, let alone dominance. And yet the work of those who are drawn by wonder to the movements and

machinations of these beings creates a space where we can imagine a more expansive and robust approach to global health, even in the aftermath. Calling from the limits of multispecies coexistence and anthropocentric intervention, rising above imperial legacies and humanitarian conventions, it is a call for a global health practice open to diverse, experiential ways of knowing and doing human health: a global health dignified by the publics it animates and the futures that their care, hope, and conviction set in motion.

Notes

PREFACE

1. Bart was asked to refrain from washing on testing days, but he was allowed "close-fitting" underwear (De Jong and Knols, "Selection of Biting Sites," 80–84; Knols, "Behavioural and Electrophysiological Responses," 151–59).

2. Improbable Research, Ig Nobel Prize Winners, 2006, accessed July 29, 2024, https://improbable.com/ig/winners/.

3. Okumu et al., "Development of a Synthetic Mosquito Lure," e8951. In following years, Fredros went on to collaborate with Brazilian entomologist Elis Batista in testing the trapping efficacy of the odor-baited traps on different *Anopheles* species, pursuing increasingly frugal designs (Batista et al., "Semi-Field Assessment of the BG-Malaria Trap," e0186696).

4. Susannah Palk, "'Dirty Sock Smell' Lures Mosquitoes to a Sticky End," *CNN*, July 26, 2011, https://www.cnn.com/2011/WORLD/africa/07/26/tanzania.malaria.socks/index.html.

5. "The Leading Global Thinkers of 2016: Fredros Okumu," *Foreign Policy*, December 12, 2016, https://2016globalthinkers.foreignpolicy.com/2016/profile/fredros-okumu.

6. According to Marilyn Strathern, "social anthropology has one trick up its sleeve: the deliberate attempt to generate more data than the investigator is aware of at the time of collection. Anthropologists deploy open-ended, non-linear methods of data collection which they call ethnography. . . . In the field the ethnographer may work by indirection, creating tangents from which the principal subject can be observed (through the 'wider social context'). But what is tangent at one stage may become central at the next." Strathern, *Commons and Borderlands*, 5–6.

7. Ngai, *Theory of the Gimmick*, 93.

8. Tsing et al., "Bodies Tumbled into Bodies," in *Arts of Living on a Damaged Planet*, M8.

1. Finlay, "El mosquito," 147–69. See also Stepan, "The Interplay," and Espinosa, *Epidemic Invasions*. Finlay initially narrowed the identification to mosquitoes of the genus *Culex*. He would later identify the vector species as *Culex fasciatus*, later renamed *Stegomyia fasciata*. The current name, *Aedes aegypti*, was formally adopted in 1964.

2. On the influence of Manson on Finlay's work, see Delaporte, *History of Yellow Fever*.

3. Orenstein, "Memorial Address," 101. Finlay would be vindicated in 1900 by Walter Reed, who confirmed his theory using similar experiments but on patients suffering a more acute form of the disease. Finlay did not receive full recognition for his original observations, a slight that was the subject of a legal suit brought by his son against the Reed Commission. See Finlay, "Carlos Finlay and Yellow Fever."

4. Around the turn of the century, other insects were being identified as agents in the transmission of disease, most notably the tsetse fly for sleeping sickness (trypanosomiasis), triatomine bugs for Chagas disease, and phlebotomine sand flies for leishmaniasis.

5. McNeill, *Mosquito Empires*.

6. See, for example, Ahuja, "M Is for Mosquitos"; Ford, "Role of the Trypanosomiases"; Packard, "Maize, Cattle and Mosquitoes"; Vail, "Ecology and History"; Sutter, "Mosquito Control"; and Deb Roy, "Quinine, Mosquitoes and Empire."

7. Stern, "Yellow Fever Crusade"; Bhattacharya, "Logic of Location"; Schumaker, "Slimes and Death-Dealing"; Kelly and Lezaun, "Walking or Waiting"; Mitchell, *Rule of Experts*; Gandy, *Fabric of Space*; and Oluwasegun, "British Mosquito Eradication Campaign."

8. See Anderson, *Colonial Pathologies*.

9. Mavhunga, *Mobile Workshop*.

10. Deb Roy, "White Ants, Empire."

11. Cummiskey, "Ecological Experiment on the Grand Scale"; see also Vaughan, "Research Enclave."

12. For Brazil, see Benchimol, *Dos micróbios aos mosquitos*; Benchimol and Cândido da Silva, "Railroads, Disease"; for Argentina, see Carter, "Development Narratives"; and for Mexico, see Stern, "Buildings, Boundaries, and Blood."

13. Aguiar González de la Peña and Benítez Piñón, "Aproximación a la historia."

14. See, for example, Beinart et al., "Experts and Expertise"; Palladino and Worboys, "Science and Imperialism"; Tilley, "Ecologies of Complexity"; Bayley, *Empire and Information*; Poleykett and Mangesho, "Labour Politics."

15. Amrith, *Decolonizing International Health*, 15.

16. Stapleton, "Lessons of History?"; Kinkela, *DDT and the American Century*; Stepan, *Eradication*.

17. See, for example, Nájera et al., "Some Lessons for the Future."

18. World Health Organization, *Achieving the Malaria MDG Target, 16*. These numbers were educated guesses and in some cases, retrospective estimates. One of the consequences of the shortcomings and fracturing of public health systems was the need to rely on mathematical models to produce plausible representations of disease incidence.

19. James, *Will to Believe*.

20. James, *Pragmatism*, Lecture 4 (The One and the Many), 52, 62.

21. James, *Principles of Psychology*, 488; "Is Life Worth Living?," 22.

22. West, *American Evasion of Philosophy*.

23. James, "Hidden Self," 249. See also Savransky, "Pragmatics of a World To-Be-Made."

24. Peirce's notion of science is grounded in the collective nature of reasoning. "This community [of inquiry]," he writes, "must not be limited but must extend to all races of beings with whom we can come into immediate or mediate intellectual relation. It must reach, however vaguely, beyond the geological epoch, beyond all bounds. . . . Logic is rooted in the social principle" (2.654). Inquiry is never a merely private interest; it "is of a nature as wide as the community can turn out to be" (5.354). Peirce, *Collected Papers*.

25. Stengers, *Cosmopolitics I*, 19.

26. Latour, "Why Has Critique Run Out of Steam?"; Latour and Weibel, *Critical Zones*.

27. Bates, *Natural History of Mosquitoes*, 2.

28. Hinchliffe, "Postcolonial Global Health," 147.

29. Landecker, "Life as Aftermath."

30. Tsing et al., "Patchy Anthropocene."

31. Savransky, *Around the World*, 6.

32. Dewey, *Public and Its Problems*, 15–16.

33. Marres, "Issues Spark a Public into Being," 212, 216.

34. Kelty, *Two Bits*. On the fragile and shifting constitution of the public in the context of public health, see Langwick, "Partial Publics."

35. Tsing, *Mushroom at the End of the World*.

36. Van Dooren et al., "Multispecies Studies."

37. Cadena, *Earth Beings*; Stengers, "The Cosmopolitical Proposal."

38. Following Savransky, in relaying pragmatism we seek "to experimentally extend the thrust of [pragmatist] thought," trying to be "not faithful to pragmatism in exposition but in spirit." Savransky, *Around the World*, 5–6.

39. Brada, "Not Here," 290. Here we follow social scientific scholarship that interrogates the production of placelessness in global health; for instance, see Benton, *HIV Exceptionalism*; Gilles-Vernick and Webb *Global Health in Africa*; Herrick, "When Places Come First"; King, "Security, Disease, Commerce"; Biehl and Petryna, *When People Come First*; Street, *Biomedicine in an Unstable Place*.

40. Packard, *History of Global Health*, emphasis ours.

41. Tsing, *Mushroom at the End of the World*, 64.

42. Redfield, "Bioexpectations."

43. Beisel, "Markets and Mutations."

44. Nading, "Chimeric Globalism"; see also Adams, *Metrics*.

45. Cross and Street, "To Fail at Scale," 102.

46. Barry, "Manifesto for a Chemical Geography."

47. For a comparable use of the field guide format, see Tsing et al., *Field Guide to the Patchy Anthropocene*.

48. Myers, *Rendering Life Molecular*.

49. Savransky, *Around the World*, 36.

50. Berlant, *Cruel Optimism*.