Mosquito Revolutions: Disease, War, and Independence in the U.S. South, Haiti, and Venezuela, 1776-1825

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I want to begin by thanking Dave Hsiung for the generous introduction, and I will have a few comments about that introduction in just a moment. It deserves a modest rebuttal. I also want to thank the McQuaide family for making the McQuaide lectureship possible. I want to thank all of you for coming out this chilly night. I understand you could be freezing your tails off tenting out on the quad.

So, as Dave said, it is true that I am entitled to teach heart surgery or brain surgery or tort law. But I want to assure you, just in case someday you find yourself in the greater Washington, D.C., area in need of heart surgery, I have not taught anybody heart surgery. The people trained at Georgetown Medical Center are trained by competent professionals in their field. So you need not worry if you're having open heart surgery.

I'm going to talk about some of the ideas and stories that went into that book that Dave mentioned, *Mosquito Empires*.[1] I will begin by explaining how I got there, which I hope will be at least of moderate interest to the people in the room who have unforeseeable paths ahead of them. And the point of this digression—a digression before I even start, maybe it's a pre-gression—is that you never know where you're going to end up or how you're going to get there, but you should be open to serendipity along the way. I found myself as a graduate student working in Archivo General de Indias, an archive in the wonderful city of Seville in southern Spain. The reason I chose the topic I did was so I could spend many months as an impoverished student in Seville. I wrote a Ph.D. dissertation which is justifiably neglected. After that I was for two or three years flamboyantly unsuccessful in the academic job market, making my living in various ways and still keeping my hand in academically by doing things such as writing conference papers.

Conference papers: you go to a gathering of scholars like yourself, you give a paper, and then they criticize you for it. I delivered my first ever conference paper in Tuscaloosa, Alabama. It was based on some research I had done for my dissertation, but hadn't been able to get into the dissertation—

leftovers. It was about yellow fever and the health establishment on the island of Cuba in the eighteenth century, something that, apparently, only a small fragment of humanity actually cared about. I gave this paper in Tuscaloosa. My hands were shaking. It was the first time I had ever done this. And then I put it aside, didn't think about it. My luck changed in the academic job market and I started teaching. A couple of years later I was walking through the library at the university where I now teach, Georgetown. There was a book on the shelf with an interesting title, so I picked it up off the shelf, opened it up, and chapter two was by me. It was my conference paper from Tuscaloosa, Alabama, that had been published without my knowledge, without my permission, and without any improvements that I might have wished to make. So, and the professors in the room may appreciate this part, I scurried back to my office as fast as I could, and I entered a new line in my c.v. But I knew that the chapter wasn't all that great, and so among my reactions was that I promised myself that one day I'm going to get back into this. I'm going to do the research more thoroughly. I'm going to educate myself more completely about the context. I'm going to do a better job. And I let life get in the way for about eighteen years, but then I did that. And that's how I came to this subject of yellow fever, and I learned later that I had to put malaria into the equation too.

Yellow fever and malaria in the political history of the Caribbean—actually, I'm going to say "greater Caribbean" instead of the "Caribbean." What I mean by that is the plantation zone, where there

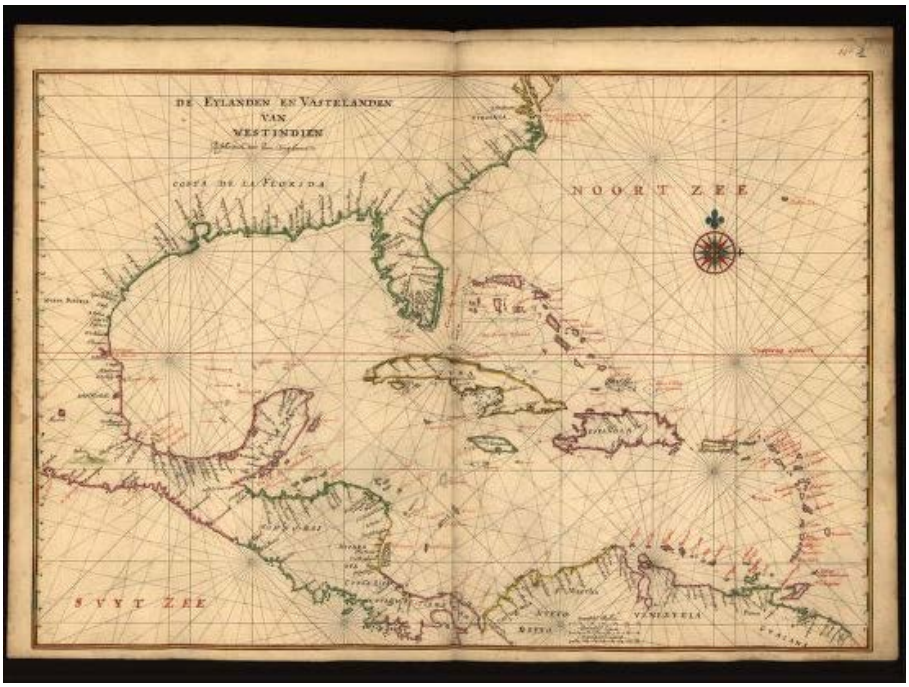

Figure 1: The Greater Caribbean, where plantations, warmth, humidity, ports, and dense populations overlap. (Map by Joan Vinckeboons. "De Eylanden en Vastelanden van Westindien." [Henry Harrisse collection ; v. 1, map 1], 1639. Image courtesy of the Library of Congress, Geography and Map Division).

used to be slave plantations—cotton plantations, sugar plantations, some other kinds of plantations. Basically, it goes from the Chesapeake region, Virginia and Maryland, south through the Caribbean to the northern coasts of South America, and you could even say it extends as far as northeastern Brazil. I'll be talking about what is now Haiti, which used to be called Saint Domingue when it was a French colony. I'll be speaking about the coasts and interior of Venezuela, and I will briefly mention the island of Cuba, particularly the Havana region.

I want to emphasize two things in talking about yellow fever and malaria in the political history of the Caribbean region. First, I am consciously trying to put together the kind of history that I specialize in, environmental history, with more traditional and venerable concerns of historians and people in general such as wars, revolutions, imperialism, and slavery. I'm trying to bring environmental history into these concerns. Secondly, I'm trying to use the environment and mosquitos and disease to bring together episodes in the history of the Americas that are otherwise thought of as quite distinct. So I'll be talking a little bit about the American Revolution. I'll be talking about warfare in Venezuela. These things are normally part of either U.S. history or Latin American history, but I'm going to lump them together and try to show you that there's an important set of common threads in this. So I'm using the environment as a way to look at familiar historical events in a new light. At least that's what I think I'm doing; you might develop your own opinions.

Here is the quick version of the argument I am presenting to you tonight. Point one: The whole Caribbean region was recast ecologically, mainly because of the plantation economy, in ways that made it more hospitable to the mosquitos that serve as vectors for yellow fever and malaria. You are going to learn more about these mosquitos than you ever wanted to know in the next ten or fifteen minutes. Point two: Different people, depending mainly on where they were born and raised, had different degrees of susceptibility or resistance to these two diseases. That made all the difference politically in terms of who survived and who died. And it is that, who survived and who died, that decisively influenced both settlement patterns and military events in the region (especially in the revolutionary wars that I'm going to focus on). Throughout, I'm going to be trying to intertwine the study of history and what I suppose you could call the study of natural history. This is really what environmental history is all about, but I am going to be making some leaps of faith, some inferences, talking about things that I think happened for which I have virtually no evidence, and unlike a lot of scholars, I am going to admit it right now, and I'm not ashamed of it. In fact, I think it's an important thing for historians and other scholars to do.

I liken this to dark matter in the cosmos. Those of you who follow astronomy know that most of the stuff out there in the universe is dark matter. Astronomers can't see it, even with all their fancy instruments. But they know it's there because of the effects it has on things they can observe, mainly gravitational effects. So, they hypothesize the existence of dark matter. I'm going to hypothesize the

existence of certain kinds of mosquitos, certain mosquito behavior, etc. These mosquitos didn't leave memoirs or correspondence; I'm making a lot of this stuff up. But, I am admitting it. And I think it's right. I think it did happen the way I'm going to claim it happened. At any rate, I'm unabashedly venturing into the dark matter of history. And some historians would say this is illegitimate: If you can't document it, you can't say it. I am not in that camp.

So let's talk a little bit about the diseases and the mosquito that carries the disease of yellow fever. The first thing you want to know is that you don't want to get this disease. It's extremely dangerous. Highly lethal if you get it even today—there is no cure. And in the bad old days, when people were malnourished, it was even more lethal. There is a lot of historical evidence for rates of mortality in affected populations of 50%, 70%, 80%, making yellow fever one of the most dangerous of all human diseases. Nowadays, it doesn't get much of a chance to run amok because there is a vaccine and the mosquito has been controlled. But in the bad old days, it often could run amok amongst vulnerable populations. The symptoms are really grisly; they don't make good after-dinner conversation. But, I will say for my purposes, yellow fever has one really good symptom, which is vomiting up partially coagulated blood, which looks like coffee grounds and has approximately the same consistency. This is good for me because it's the kind of symptom people wrote about when they saw it. It's distinctive. Not quite unique but really close to unique. That is good because it helps me identify highly probable cases of yellow fever. Historical retrospective diagnosis is always difficult. Doctors get it wrong half the time even when they can examine patients, so think how hard it is to do it for someone who died in the eighteenth century. But this particular signature symptom of yellow fever makes it a whole lot easier.

The disease is originally an African one. This used to be uncertain until the late 1990s, before which some people thought it was an American disease and some people thought it was an African disease in origin. That has been resolved through analysis of the virus's DNA. It came to the Americas sometime before 1650, maybe in the early 1640s, maybe a lot earlier. Maybe it was introduced many times. I don't know. It is a mosquito-borne disease. Outside of rain forest canopies, only one species of mosquito carries it, *Aedes aegypti*, which I will tell you about in just a moment. But a little bit more about the disease first.

Historically in the Caribbean, it was a disease of newcomers, at least after the 1640s. People who had been born and raised there almost never got it. The reason for that is that the disease is very dangerous to adults, especially young adults, but it goes easy on little kids. So, if you are born and raised in a place where yellow fever is endemic, or constantly present, you get it as a little kid and you might not even show any symptoms, you might not even know you're sick. The good news is if you live through it, as almost every little kid does, you're immune for life. If you get it for the first time at age eighteen or twenty-two, there is an excellent chance it will kill you. The prevalence of the disease in men versus

women is interesting. The seventeenth- and eighteenth-century sources say that men were much more likely to get and die from yellow fever than were women. Probably, if it was true, and I'm not sure it was, it was a matter of exposure to mosquito bites. Men were more likely to be outside and more likely to be doing things that attract mosquitos, such as exercising vigorously and sweating a lot. Mosquitos sense you by your sweat and your carbon dioxide exhalations. Another interesting question is whether there's heritable immunity. What I talked about a moment ago is acquired or conferred immunity, by getting the disease and getting through it. There may also be heritable, genetically communicated resistance or even immunity to yellow fever. Nobody knows for sure. When I first became interested in this subject, I thought probably there was. Now, I think probably not. It's kind of complicated. But in the seventeenth and eighteenth centuries, just about everybody thought that Africans and people of African descent were either resistant or immune by nature to yellow fever, which is probably not true.

Figure 2. *Aedes aegypti.* (Photo as appeared in "Imported dengue fever and dengue hemorrhagic fever in Japan, April 1999-December 2003." *IASR* 25, no. 2 (2004): 26-27. http://idsc.nih.go.jp/iasr/25/288/tpc288.html).

Now, a little bit about the mosquito. I was about to say itself, but maybe I should say herself, because it's only the females that matter. Only females bite mammals, and only females communicate the virus of yellow fever. Like all mosquitos, *Aedes* is temperature sensitive. It's really happy between 85 and 95°F. And if it's cooler than that, it gets a little sluggish. And if it's a whole lot cooler it's dead. The feeding focus of a mosquito is also really important. Female mosquitos need blood meals—they have to

bite mammals in order to produce eggs and reproduce, which is a big part of their agenda in life. Some of them will bite any kind of mammal: squirrels, rhinoceros, what have you. But some have strong preferences. *Aedes* really likes human beings and will only bite other mammals if there are no humans to be bitten. That is its so-called feeding focus. And that makes it an efficient vector for disease because it's not injecting its virus into cats or rabbits. It almost only bites human beings. It is really a domesticated animal because of its feeding focus and its unique breeding habits. Every other kind of mosquito on earth likes to lay its eggs in puddles and swamps and other natural settings. *Aedes aegypti* likes to lay its eggs in artificial water containers such as jars, pots, wells, cisterns, or barrels. If it's made of out of wood, or concrete, or plastic, that's where this mosquito likes to lay its eggs. No other mosquito does this. Really weird. Probably, it bespeaks a long history of interaction with pottery-making populations in West Africa. But that's the rawest of speculation.

So that means *Aedes aegypti* lives only in association with human beings. It's rarely found over a hundred yards away from human settlement. It's also, however, a good shipboard traveler, because ships always have stored water on them. That's a great place for the mosquito to lay its eggs. Just in case I've scared you enough that you're interested in the distribution of yellow fever today, it is still endemic in parts of Central and South America and Africa. For those of you who are contemplating study abroad experiences or going to see the world after you graduate, you might want to take this into account. Really, all you need to do is get a yellow fever vaccine, and you don't have to worry about it. Juniata has a program in the Gambia, for example, which is in the endemic yellow fever zone. You better get your vaccine if you want to go anywhere near the Gambia. And the mosquito is changing its geographical distribution mainly in response to mosquito control programs. Between the 1930s and 1970s, in the Americas, the mosquito's range was constricted through mosquito control. But since 1970, it's been making a comeback. It has colonized the southern United States, the Gulf Coast, and Florida. There's normally no yellow fever there. The same mosquito can also communicate dengue fever, which is starting to show up more and more on the Gulf Coast and Florida. But it will be a long time before central Pennsylvania will be warm enough for *Aedes aegypti* to survive.

Now let's switch subjects to malaria. Malaria is not as lethal as yellow fever. Even the nastiest kind, *Plasmodium falciparum* malaria, kills only about ten percent of the people who host the disease—a big enough proportion, but small compared to yellow fever. Most of the forms of malaria are much less deadly than that. *P. vivax*, which is more common than *P. falciparum*, kills only about one percent of the people who get it. Resistance and immunity to malaria is really, really complicated. The short version is that you can get it many times, unlike yellow fever which you get only once, if that. Yellow fever either kills you or makes you immune for life. Malaria you can host dozens of times. The more times you live through malaria the stronger your resistance. So people who grow up in endemic malaria zones are

highly resistant, but they are never immune from prior exposure to malaria. Some people are immune to *P. falciparum* malaria. These are a goodly proportion of people in West and West Central Africa and a smallish proportion of African Americans. And that is through the so-called sickle-cell trait, which comes at a cost of heightened risk for iron anemia.

Malaria is African in origin, like yellow fever. Unlike yellow fever, it is more a rural disease than an urban one. That's mainly because of the habits of the mosquito vector. It's also much less lethal. There are many species of mosquitos that can carry malaria. They are all from one genus, called *Anopheles*. And in North America, there's only one important *Anopheles* vector called *quadrimaculatus*. The whole southeastern and even northeastern part of North America is colonized by this mosquito. It would be all over Pennsylvania in the summertime, I am sure, even though I haven't taken a census of your mosquitos. They are, most of them, malaria-competent. And in fact, I'm sure that in the early nineteenth century, there was malaria in Pennsylvania. But that is no longer the case. In the Caribbean, there is a somewhat different species. So that's more than you ever wanted to know about mosquitos, and the yellow fever virus, and malarial plasmodium and resistance and immunity thereto.

These infections became important in the Americas around the 1640s, and my belief is that part of the reason was that beginning in the 1620s, the Caribbean and also northeastern Brazil were transformed by the sugar economy. Sugar plantations and slavery had a suite of ecological and demographic effects, some of which I'll mention in the context of Caribbean islands such as Barbados.

Figure 3. Sugar Plantation ("View of a Sugar Plantation, French West Indies, 1762;" Image Reference gazz02, as shown on http://www.slaveryimages.org, compiled by Jerome Handler and Michael Tuite, and sponsored by the Virginia Foundation for Humanities and the University of Virginia Library).

One effect was deforestation. In order to put in sugar plantations, people had to cut down and burn down the forests, with effects upon bird populations. Now this is partly dark matter, hypothesis, but there's actually some evidence in some of the writings from the seventeenth century of people saying, there used to be birds here, but now I don't hear any birds after twenty years of sugar plantations. So I'm probably not making that part of it up. Deforestation also meant heightened rates of soil erosion and soil deposition along the coasts, which caused the building out of swamps where every creek reached the sea. It was great for the mosquito populations, at least the *Anopheles* mosquitos. The *Aedes aegypti* wouldn't care; they don't like swamps. But that was more habitat for the malarial mosquitos. I should say that this was not the case in Barbados because this was and is the only island in the Caribbean that doesn't have *Anopheles* populations.

The sugar plantation economy also meant more port cities because it was an export economy. Sugar had to be shipped to places such as Philadelphia, London, Amsterdam, Bordeaux, and Seville. So port cities grew up and port cities are important because of stored water, which is *Aedes aegypti* breeding habitat. Every port city has to have the facilities to store a lot of water. It's got to have cisterns, wells, what have you. It's got to keep barrels of water lying around to put on ships. In short, the sugar plantation economy, through a couple of intermediate steps, produces mosquito paradise, both for *Anopheles* and for *Aedes aegypti*.

Now for a little bit about the plantation environment itself. The islands were deforested substantially to produce the sugar plantation environment. This resulted in fewer birds, which were the main predators upon adult mosquitos, and therefore reduced predation on adults. More importantly, they had food in the form of mammals, both livestock and human beings, mainly slave laborers, for female mosquitos to get their blood meals. But they also had sweet fluids, which every mosquito, male or female, likes. The sugar cane is ideal. They could just stick their proboscis right into a stalk of sugar cane and draw out nutrition. And that's important because it meant that the mosquitos lived longer because they had a reliable food source. And long-lived mosquitos are more dangerous mosquitos from the human point of view, because they're more likely to have bitten someone who gave them either the yellow fever virus or the malarial plasmodia. So young mosquitos aren't that dangerous because they haven't bitten anybody yet, but old mosquitos, grandmother mosquitos, are the most dangerous from the point of view of disease transmission. And also, the last thing about sugar plantations is they had pots on them that collected rainwater. They had pots that were shaped like cheerleader megaphones. These were used in the initial stages in sugar refining, whereby juice is transformed into crystals. For two or three months of the year, these things were full of sugarcane juice, slowly becoming crystals. The rest of the year they were empty. They were made out of clay. They caught rain water and were incubators for *Aedes aegypt*. These were the perfect place to lay their eggs and there were thousands of these on a good-

sized plantation. So for these various reasons, not just the sugar economy, but the precise environment of the plantation itself, it was the best of all possible worlds. If you had asked mosquitos to devise a world suited to their requirements they would have come up with a sugar plantation with a few port cities around it. And that, inadvertently and accidentally, is what people put into the Caribbean in the seventeenth and eighteenth centuries.

Now, I am not going to tell you about how the presence, the hyperendemicity, the constant presence of yellow fever and malaria helped Spain to defend its empire against British and French attacks (although it is pretty fascinating). Instead I am going to tell you about revolutions and how mosquitos and disease helped revolutionaries win their revolutionary wars. And for the three cases I'm going to talk about, the key is that people, locally born and raised in the greater Caribbean, had either resistance or immunity to both of these diseases. And folks coming from elsewhere in the world, unless they came from West or Central Africa, did not have the requisite immunities. And therefore, coming as adults, particularly in the case of soldiers, they were maximally vulnerable and died in droves. So the diseases were not random in their impact; they were partisan, systematically partisan in their impacts because of this differential resistance and immunity on the part of different populations. That is why they were politically important and historically important. So let's begin with the American Revolution. You have, at least if you've been in Dave Hsiung's class, learned a lot about the American Revolution. But, I don't know, maybe he does teach you about mosquitos; I wouldn't put it past him. But if he does, he's the only person who mentions mosquitos in the history of the American Revolution. So as you may recall, soon after the war broke out it was a bit of a stand-off and stalemate. Americans controlled most of the countryside. The British, as a naval power, controlled most of the important port cities. Neither was able to dislodge the other and win the war. It dragged on. And most of the maneuvering in combat was in the New Jersey, New York, and easternmost Pennsylvania area.

So the grand strategists in Britain decided they needed to force matters to a conclusion. Their approach to this was their Southern Strategy. They were going to send a big army to South Carolina. If they did this they hoped they would cut off some of the revenues of the Americans, because some of that came from the rice economy of the Carolina and Georgia coasts. They would energize large numbers of so-called loyalists, people who they believed were loyal to the British crown. And with this they would get the war won quickly. They needed it done quickly because the international situation was going against them. Other powers were joining against Britain, so they had to force it to a conclusion. Unfortunately for them the mosquitos had a different idea.

Within the war of the American Revolution, there was another contest going on between microbes: smallpox versus malaria. The Americans, born and raised for the most part in the rural areas of eastern North America, had generally grown to adulthood without any prior exposure to smallpox. They

were vulnerable. And when they congregated in big groups they often created little smallpox epidemics in their regiments, their army encampments, and their cantonments. George Washington had a solution to this, which was so-called variolation. It's kind of like a predecessor to vaccination. A tiny little cut was made on the arm, a little live smallpox-infected material was rubbed in, and they hoped for the best. And in about ninety-eight percent or so of cases that meant that somebody would get a little bit sick but emerge immune to smallpox. In one or two percent of cases it would kill the unfortunate guy, but Washington mandated this for the Continental Army. The British, as I'll explain in a moment, suffered more from malaria and couldn't do anything like that about it. This is really important because in the American Revolution, as in all wars before the twentieth century, far more people died from disease than from combat. In the British Army, that ratio was about eight disease deaths to one combat death. For the Continental Army the data is a lot fuzzier, but the ratio was probably higher, though not quite twice as high. There's a great book, by the way, about smallpox during the American Revolution by Elizabeth Fenn, so I recommend that to you if you have any interest in this.[2]

So, Washington mandated variolation for everyone in the war who was going to join the Continental Army, and it was one of the best decisions he made in the course of the war. Even so, the Continental Army lost 50,000-70,000 men to disease and about 4500 to combat. These are rough figures in both cases, and a lot of other diseases are in play as well, typhus and dysentery among them. But the lesson here is that the Continental Army could control smallpox.

Something of the same ecological transformation took place in the South as took place in the Caribbean islands with the sugar economy. But here, it was rice in the so-called lowcountry: coastal Georgia, South Carolina, and North Carolina. Ditches, seasonal irrigation, water on the land for months of the year. In short, it was ideal habitat for *Anopheles*, the malarial mosquito. Around the world, there is an affinity between malaria and rice production. In Italy, East Asia, South Asia, and everywhere there is rice, there is more malaria than in surrounding districts. Beyond the good breeding habitat, plantations also mean good feeding opportunities for mosquitos with lots of livestock and lots of humans. And the *Anopheles quadrimaculatus* are happy to bite livestock as well as to bite humans.

In the British Army this was a particular problem because most of the people in that army had been raised either in Britain or in Germany, and comparatively few of them had any prior exposure to malaria and hence were not resistant to malaria. And as a result, the moment it got warm enough for the mosquitos to be actively flying and biting after the British Army had installed itself in South Carolina, they started having their own epidemics to which the locally born and raised population of South Carolinians was largely, though not entirely, resistant. Little kids would still get it badly, but most adults

Figure 4. View of a Rice-field in South Carolina. (James Well Champney, *View of a Rice-field in South Carolina. [Page 434.]*. Documenting the American South. University Library, The University of North Carolina at Chapel Hill, 2002. http://docsouth.unc.edu/nc/king/ill283.html).

would not. This was especially important for the British Army in the summer months of July through October. Half of their men typically were sick, and that meant that they couldn't move around. They couldn't move the army around; they couldn't leave these guys behind; they had to protect them, and not leave them subject to the tender mercies of people like the Swamp Fox, Francis Marion. So it constrained their strategy as well as deprived them of about half their manpower in the summer months.

There was one thing you could do about malaria at the time of the American Revolution: provide the bark from the Cinchona tree (sometimes called "Jesuit bark"), which would relieve malarial symptoms reasonably effectively. But it only came from a place in South America, and the British couldn't get much of it. They could get less of it after Spain joined the war against Britain and started preventing its export to Britain as a strategic military good. It was expensive, and the British needed it in India, and they needed it in the West Indies. Using it in South Carolina wasn't the highest of their priorities. Washington didn't have the constraint on his medical intervention that the British did.

After January of 1780, there was a big British army operating out of Charleston, South Carolina. This army was running around and chasing Continental Army forces, who were usually clever enough not to give decisive battle. That, in a nutshell, was the way the war in South Carolina was conducted in 1780 and 1781. The British forces were led by Lord Cornwallis. He started out with about 8000 men and got a few reinforcements. And they were chasing Nathanael Greene, who had quickly succeeded to command of the Continental Army in the South. Nathanael Greene typically would, in effect, run away,

Figure 5. Cinchona tree and bark. ("Cinchona Tree." *Beez Neez* Last modified February 24, 2009. http://blog.mailasail.com/beezneez/177).

and the British would chase him. There were only a handful of significant battles. If Cornwallis kept his troops near the coast, they could be resupplied with food and ammunition, but they couldn't be kept healthy in the summer months. In the lowcountry of South Carolina, they were going to get malaria. If they went to the upcountry, two hundred miles inland, they'd be a little bit healthier but they couldn't easily be resupplied. So he was between a rock and a hard place. *Anopheles quadramaculatus* had the most straightforward of strategies: just bite mammals wherever you could find them.

Cornwallis recognized this after the first summer, the summer of 1780, when more than half of his army was sick, and as he anticipated the next summer, 1781, he decided he was going to get out of South Carolina. He wrote to his commander in New York that he was obliged to move to the upper parts of the country where "alone I can hope to preserve the troops from the fatal sickness which so nearly ruined the army last autumn." He went to the Piedmont in Virginia beginning in April of 1781. There were a few battles here, mainly a split decision, but ultimately inconsequential to the outcome of the war, whatever military historians may say. So his commanding officer in New York said, "Don't go to the Piedmont, I need you near the coast where I can summon you to New York at a moment's notice by sea if I have to." Cornwallis had to obey commands, and he took up a position at Yorktown in the tidewater region of Virginia. Yorktown on an eighteenth-century map appears as lots of swampy creeks and low-

lying coast. Cornwallis recognized that it was a sickly defensive post, and he questioned the wisdom of his superior in sending him there, but he didn't have any choice in the matter. He was a military officer.

Figure 6. Plan of Yorktown. Note the swampy creeks.
("Plan of York Town and Gloucester in Virginia, Shewing the Works Constructed for the Defence of Those Posts by the Rt. Honble: Lieut. General Earl Cornwallis, with the Attacks of the Combined Army of French and Rebels under the Command of the Generals Count de Rochambaud and Washington Which Capitulated October 1781." Map, 1781. United States. Image courtesy of the Library of Congress, Geography and Map Division).

In the summer of 1781, Cornwallis ensconced his army at Yorktown, and they were soon enough cut off from reinforcement and resupply by a naval battle with the French fleet that had just come up from the Caribbean. So Cornwallis was stuck inside the Chesapeake, inaccessible to British naval power. And as soon as that happened, Washington, in what might have been the second-best decision he made during the war, hightailed it from New England, where he was camped out, all the way down through New Jersey and Delaware, took a boat along the Chesapeake, and besieged Yorktown together with a French general, Rochambeau, who was in Rhode Island at the time he began to march south. So they got there in

the middle of September and the besieged the British Army in their encampments at Yorktown. And I will skip over the mechanics of siege warfare and explain that Cornwallis, who surrendered, was no incompetent. He knew what he was doing. He was an experienced soldier. He was recognized for his achievements after the war, given high office, and enobled. He was not regarded as a dolt who did the wrong thing at Yorktown. He conducted his business as competently as could be done, but he lost, and he surrendered.

His explanation of his surrender written to his superior afterwards includes these interesting phrases: "The troops being much weakened by sickness." "Our numbers have been diminished by the enemy's fire but particularly by sickness." "Our force diminished daily by sickness." In fact, according to the returns prepared by his subordinate officers at the time of the surrender, 54% of his army was dead or sick. About five hundred of them had been killed or wounded in action, the rest of them incapacitated by disease. There's a lot of evidence for malaria in this, but no doubt other diseases were involved. So I'm suggesting here that the outcome at Yorktown was powerfully influenced by the differential resistance to malaria on the part of the British, the Continental, and the French armies.

So why didn't the Americans and the French get sick too? Well, to a small extent they did, but most of the Americans were young men from the southern colonies. They'd grown up with malaria. They had resistance to it. As for the French forces, most of them came from prior postings in the West Indies, where they too had malaria, although not as frequently as the Continental Army troops. Also important, they didn't get to the region until September, so the mosquitos didn't have all that long to bite and infect these guys before the siege was over, about a month afterwards. The British Army had been there since June; they had been bitten and bitten and bitten again. They had absorbed heavy doses of malarial plasmodium, so more of them got sick. After the siege was over, the New England troops especially did get sick from malaria, but it didn't matter. Politically and militarily it was all over. So that's the American Revolution case.

Now I'm going to say a few words about the Haitian Revolution, 1791 to 1804, in which yellow fever played the decisive role. This begins with a slave uprising in the late summer of 1791. The British Army tried to intervene even though this was a French colony, Saint Domingue. They didn't want slave insurrections in the West Indies, so they tried to prevent the slave uprising from succeeding and put an army in to occupy Saint Domingue. One of their doctors said, "Don't do it. Two-thirds of European soldiers will perish before the end of the year." A mild exaggeration, but before the British gave up, they lost 15,000 of their 23,000 soldiers to yellow fever. There was very little combat against the slave army, who was led by Toussaint Louverture.

Toussaint, I think, understood differential resistance and immunity. He didn't understand the mechanisms of it, but he conducted his war as if he knew that his guys, mostly African-born slaves, were

more likely to survive the rainy season, the disease, the fever season in Saint Domingue—much more likely than the French Army or the British Army. Why do I think so? First of all, Toussaint was attuned to medical matters. He worked as a veterinarian and worked in a hospital when he was a slave. When the insurrection began, this is the title he gave himself on his correspondence: Médecin Général. It's like the surgeon general of the slave army. Then, in a document from 1802, Toussaint wrote to one of his generals that, and I'll translate this for you, "Waiting for the rainy season which will rid us of our enemies, we only have as resources—or weapons—destruction and fire." The important part is the first phrase: "Waiting for the rainy season that will rid of us of our enemies." He knew that the rainy season was going to kill off the French Army and leave his guys comparatively unscathed. This was a piece of correspondence of his that was captured by the French Army and preserved in archives. Thank heavens. The outcome after the French sent an army, a really big army of more than 60,000 men into Saint Domingue, was that almost all of them died from disease. About 1000 died in combat and upwards of 50,000 died from disease. Overwhelmingly, but not exclusively, it was yellow fever.

My next example is the case of Venezuela. Starting in 1808, wars of independence broke out all over the place in Latin America against Spanish rule. One of those places was Venezuela. Back in Spain, between 1807 and 1812, Spaniards were fighting hard to drive out Napoleon's French troops. Once they did that, their newly reinstated king decided he wanted his empire back in the Americas, and he decided to send a big army somewhere to start winning against revolutionaries in South America. And he chose Venezuela.

He should have asked me. I would have said, "Don't do it! Don't go to Venezuela! There's yellow fever and your whole army is going to die!" He should have gone to Chile, or Argentina, or the highlands of Mexico, but he made a crucial mistake. Along the coasts there was yellow fever in the port cities. Inland, in the seasonal wetlands called the llanos of Venezuela, there was malaria. It is the most intensely malarial zone in Latin America today, and it probably was in 1815 as well. To make it worse, in the context of this war of revolution, a large proportion, 95%, of the livestock was also killed because people needed to eat it. And that meant that the feeding focus of the *Anopheles* mosquitos in Venezuela narrowed because there weren't that many livestock left. They were more likely to bite humans.

So the Spanish general sent to command these forces, Pablo Morillo, by all accounts was a man terrific at his job. He took an army of 17,000 into Venezuela and 90-97% of them died there. Less than 3% died in combat, the rest of them from disease—a lot of different diseases, but certainly yellow fever and malaria. He noticed this. How could he not? One of the things he wrote was that he was really irritated by these revolutionaries, because they would not stand and fight. Just like Toussaint in Haiti and just like Nathanael Greene in South Carolina, the revolutionaries in Venezuela were not going to permit a climactic battle; they were going to run away. As he put it, "They are just waiting for us all to die of

infection and disease." And why not? That's exactly what the revolutionaries should have done. Exactly what Nathanael Greene and Toussaint should have done. The main revolutionary in Venezuela, Simon de Bolivar, noticed it too. In his voluminous, and I mean voluminous, papers, like twenty-six volumes or something, he had two interesting sentences. And one of them is this: "We lament the infinite sickness that has considerably reduced our troops (the revolutionaries) but we are consoled by the fact that the enemy must suffer greater losses." Greater than infinity. Obviously his mathematics education was not perfect. The enemy would suffer greater losses partly "because of the nature of his soldiers and partly because of the positions he occupies."

Bolivar was confident that the Spanish Army was going to die from disease even faster than his own army. Partly because of the "nature of his soldiers"—he was talking about the bodily vulnerability of the Spanish troops as opposed to people born and raised in Venezuela. He didn't understand immunity or resistance, but he somehow located it in their bodies. And "partly because of the positions he occupies." He tried to keep the Spanish Army pinned in those coastal lowlands where there's yellow fever and keep them out of the mountains where it would be cooler with fewer mosquitos and fewer fevers. So he was on to something, even though he had a minimal medical understanding, at least by our standards. The other interesting sentence in his correspondence and memoirs is that he recruited from the lowlands because he had learned that men from the cold uplands—this really means Colombia, not Venezuela—all "died in Venezuela as sadly we have learned." Not everybody in the Americas was resistant to malaria. People in the mountains, at eight thousand feet, nine thousand feet—and there is a lot of Colombia that is that elevation—didn't have exposure because they lived in an environment where it was too cool for mosquitos most of the year.

The Cuban case is the same old story. Let's skip it, except for this: To appreciate this all you have to know is that Maximo Gómez is one of the great heroes of the Cuban War for Independence, 1895 to 1898, against Spain. It's the one that the U.S. jumped into in 1898; we call it the Spanish-American War. But in Cuba, it started as an insurrection of Cubans against Spanish colonial control. And in Cuba, this is associated with all sorts of nationalist mythology. Of course in the U.S. there's another cultural mythological understanding of this campaign. But the big variable in this war was captured by Gómez when he wrote in his memoirs that his victory he owed to "three invincible generals: June, July, and August." The rainy season and the yellow fever season in Cuba. Once again, the Spanish Army sent out to prevent this revolution from succeeding died in droves just like Morillo's army eighty years before, just like Charles Leclerc's army in Saint Domingue in Haiti ninety-five years before.

Okay, we are getting to the end. The basic argument is this: the ecological transformation of the plantation zone in the Americas made it more hospitable to mosquitos and the diseases yellow fever and malaria. Differential immunity and resistance on the part of populations born and raised there versus

populations born and raised particularly in Europe meant military campaigns and the geopolitics of the region were powerfully influenced by the disease factor, as much if not more so than any other context in world history, I would say. It's trivial, nowadays. Malaria is not exactly trivial, but yellow fever is trivial in the Americas due to successful mosquito control and the yellow fever vaccine. So the era in which these diseases could have this powerful political effect in the Americas ended in the early twentieth century and is not likely to return, although it is at least theoretically possible.

Some of my best friends say, John, that's all very well, but this is mosquito determinism. This is not intellectually responsible. You cannot assign causation in the course of history to mosquitos. What about people? What about powerful social forces? Okay. I'm not really a mosquito determinist even if I may sound like a mosquito determinist, because people had to do a lot of things for diseases and mosquitoes to have the consequences that they had in the greater Caribbean in these centuries. They had to make the ecology of the region more hospitable to the mosquitos, the viruses, and the plasmodia. They had to organize their economies in ways, for example, that had port cities. They had to fight their wars the way Greene, Toussaint, Bolivar, and Gómez fought their wars. In other words, mosquitos didn't do this alone. It's the fusion of human action and mosquito behavior that made the result what it was. But I think to understand it properly and fully you have to have that part of the equation, the mosquito behavior and the differential immunity and resistance.

Another thing to take away from this is the law of unintended consequences. Nobody wanted to make this part of the world a paradise for yellow fever and malaria. Nobody wanted hundreds of thousands of men to die from disease. What happened was nobody's design. It was unintended consequences of decisions taken for other reasons.

So there are a lot of questions that I'm leaving hanging. Climate change might be part of my story. El Niño events are definitely a part of my story. The difficulty of retrospective diagnosis is definitely a problem for my methodology if not my story. But I won't say anything about those. Instead, I'll leave you with this: there are the great heroes of these revolutionary wars, as they are conventionally understood, but actually the real *dramatis personae* (not really "personae" but dramatis "mosquito-ae") at the center of the story are adult female mosquitos.

NOTES

1. John R. McNeill, *Mosquito Empires: Ecology and War in the Greater Caribbean, 1620-1914* (Cambridge: Cambridge University Press, 2010).
2. Elizabeth A. Fenn, *Pox Americana: The Great Smallpox Epidemic of 1775-82* (New York: Hill and Wang, 2001).