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DISASTER VECTOR CONTROL IN MISSISSIPPI AFTER HURRICANE KATRINA: LESSONS LEARNED

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ABSTRACT. Hurricane Katrina devastated the Mississippi Gulf Coast on August 29, 2005, causing an ecological disaster. Mississippi State Department of Health (MSDH) entomologists established a vector control program in affected areas with the following objectives: 1) helping local vector control agencies reestablish services, 2) performing mosquito surveillance, and 3) establishing mosquito larviciding and adulticiding where necessary. The MSDH personnel also helped write Action Request Forms requesting assistance from the Federal Emergency Management Agency (FEMA) for increased ground spraying in the 6 lower counties. Mosquito surveillance was conducted daily for 2 wk after the storm, then weekly for another month. Sanitation lagged, with people using makeshift latrines or simply piles of rubbish for bathrooms. Filth flies contaminated food and food surfaces. Responders lived in tent cities, many allowing filth fly access. Approximately 2 wk after hurricane landfall, due to increasing mosquito numbers, MSDH entomologists requested FEMA for an aerial spraying of insecticide to reduce nuisance mosquito biting in the area. A private vendor made 1 application of naled (Dibrom®) insecticide in the 3 coastal counties, yielding over 90% control in entire counties in 1 night. No complaints or medical or environmental problems from the increased ground spraying and aerial spraying were reported. Overall, important lessons in disaster vector control were learned, including how to work effectively with Centers for Disease Control, FEMA, and the US Public Health Service personnel, how to manage the public relations/educational aspects, and how to avoid or mitigate political interference in the disaster response.

KEY WORDS Disasters, hurricanes, health department, mosquito control, public health response

INTRODUCTION

Mosquito and other types of vector control in Mississippi have always been on an as-needed basis and rarely ever forward-looking or proactive. Beginning in 1915, with help from the US Public Health Service (PHS), the Mississippi State Department of Health (MSDH) cobbled together a malaria prevention and control program that ultimately eliminated local malaria transmission in 1955 (Hataway and Goddard 2011). Twenty years later—and with no paid entomologists on staff—another vector-borne disease outbreak severely tested the MSDH. St. Louis encephalitis erupted in Mississippi during 1974–76, resulting in 331 reported cases and 42 deaths (MSDH 1976; Powell and Blakey 1976, 1977). At the time, there was a Division of Sanitation within MSDH containing a certain level of environmental health experience and an Epidemiology Division with appropriate infectious disease personnel, but no entomologists on staff. Nor was there any ongoing mosquito surveillance in the state or active monitoring system(s) for encephalitis virus activity in nature (e.g., sentinel birds). By far, the most severe test to date of the MSDH's vector control capabilities came with the arrival of Hurricane Katrina in 2005. In the 14 years since the storm, much has been written about its effects in several southern US states, such as a paper detailing lessons learned concerning health care infrastructure and the role of medical providers after the storm (Darsey et al. 2013) and the role of the US military in disaster response (Breidenbaugh et al. 2000). This paper describes the MSDH disaster vector control response to Hurricane Katrina from 2 first-hand eyewitnesses (the authors) and important lessons we learned as a result.

HURRICANE KATRINA

Hurricane Katrina devastated the 90-mi Mississippi Gulf Coast on August 29, 2005, highlighting disaster preparedness (or lack thereof) in both Louisiana and Mississippi. A more in- depth discussion of the 2 states' responses, including US Air Force involvement, is provided elsewhere (Goddard 2013). The event was a total ecological disaster due to high wind and saltwater (storm surge) washing ashore for several miles inland. At one spot near Waveland, MS, the debris line on the south side of Interstate 10, representing the water's height, was observed at approximately 25 feet high, 7 mi inland. This meant that everything in the storm surge's path was completely inundated with salt water, most of which was washed back out to sea. Accordingly, no insect or rodent problems occurred during the first week or so after the storm; however, new mosquito, filth fly, and rodent breeding began shortly after that (Table 1).

Destruction from the storm was almost unbelievable. Thousands of homes were totally destroyed, leaving nothing but foundations or slabs. Other

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Table 1. Likely vector control issues sequence after disasters.

Time (days)	Vector and result	
	Mosquitoes	Other pests
Within first few days	Nothing	—[1]
7–14	Floodwater mosquitoes such as *Aedes* and *Psorophora*. Nuisance only, not vectors of disease.	Blow flies and house flies breeding in spoiled food, dead animal carcasses, and debris piles. Possibility of diarrhea, dysentery, conjunctivitis, and other mechanical transmission of disease agents.
15–30	*Culex* mosquitoes breeding in polluted standing water and sometimes artificial containers lying around.	Blow flies and house flies breeding in spoiled food, dead animal carcasses, and debris piles.
	—	Rodents breeding in debris piles. Possibility of rat bites, leptospirosis, and mechanical transmission of disease agent.
31–180	—	Rodent breeding in debris piles.
	—	Other nuisance pests breeding in debris such as brown widow spiders, snakes, etc.

[1] No other significant problems reported.

homes, a few miles inland, were partially destroyed with roofs, windows, and doors gone. Virtually all infrastructure in the coastal counties collapsed, electric lines were downed, and sewer and water pipes broke, sending raw sewage over the ground surface. Roads, where passable, were littered with metal and wood debris, causing extremely slow traffic and flat tires. People slept either outside or inside their partially destroyed homes. Heat and humidity made life miserable. For the first week or 2, people lived on military meals-ready-to-eat or other foods stored on ice, provided by the Federal Emergency Management Agency (FEMA), the Red Cross, or the Salvation Army. Sanitation lagged, with people using makeshift latrines or simply piles of rubbish for toilets. We observed many situations where people simply urinated and defecated openly in their yards. Filth flies contaminated food and food surfaces such as tables, spoons, forks, and knives. Responders lived in tent cities, but many tents were open, allowing filth fly access.

Four days after the storm, we went to the disaster zone for a meeting with Mississippi Emergency Management personnel and the MSDH incident commander to plan the vector control response. Interestingly, at that time, no mosquitoes were seen, nor even many birds, as these seemed to be "blown out" of the area by the storm. Our objectives for poststorm vector control were fairly simple (Table 2) and included helping local mosquito and vector control agencies reestablish services, and performing mosquito surveillance, larviciding, and adulticiding where necessary. Fortunately, the MSDH is centralized, allowing easy statewide movement of people and resources. For example, MSDH environmental health specialists (EHSs) from all over the state were recruited to aid entomologists as foot patrols for larviciding. One of the most significant pest control issues after the hurricane related to the debris piles (Fig. 1). The enormity of such piles was staggering, as they contained thousands of (what used to be) people's houses and belongings decimated by the storm. Some piles reached to the top of telephone poles in height; others looked like small mountains. FEMA paid contractors with heavy equipment to clear roads and push debris from the storm into piles along the side of the road for pick up. These piles contained myriad food and breeding sites for mosquitoes, flies, rodents, and other vermin, including water in artificial containers, household food

Table 2. Mississippi Department of Health plan for vector control after Hurricane Katrina, fall 2005.

Disaster vector control objectives
1. Establish systematic mosquito surveillance in the affected counties
2. Test pools of mosquitoes for West Nile virus and other arboviruses
3. Intervene where necessary to control mosquito hot spots
4. Provide mosquito repellent free of charge to residents and responders
5. Send out teams of MSDH environmental health personnel to identify and treat mosquito breeding sites with larvicide
6. Work with local mosquito and other vector control entities to help get them back online and functioning

Fig. 1. Debris piles along streets after Hurricane Katrina often provided breeding grounds for flies, rodents, and mosquitoes.

Fig. 2. Larvicides were placed in all sorts of artificial containers holding water. Notice also the swimming pool in the background (Photo courtesy Jerome Goddard).

from freezers and refrigerators, and dead wild and domestic animals. One damaged veterinary clinic we saw had large piles of spoiled pet food thrown outside on the street—perfect feeding stations for rodents. Removal of debris piles took several months to more than a year in some areas, leading to development of other, more semipermanent, pest problems like brown widow spiders.

Working with the myriad federal agencies (FEMA, Centers for Disease Control [CDC], and the PHS) to make requests for resources and/or services was difficult. It usually involved a dizzying array of forms and requisitions sent through a maze of state and federal agencies, which unfortunately sometimes seemed to compete with each other. However, we eventually figured out how to work the system to get things done. (The problem is, will responders have to relearn this after the next hurricane?) We also learned how important it is to work with Incident Command System public information officers to inform the public about pest issues and ways for them to eliminate pest breeding and protect themselves. In addition, we worked closely with the MSDH public relations personnel to announce all vector control activities in affected areas.

Our first line of mosquito control was larviciding, based upon surveillance data when possible. We made a request to FEMA and PHS personnel for purchase of *Bacillus thuringiensis israelensis* (*Bti*) mosquito dunks and methoprene (Altoside) 30-day briquets. The EHS larviciding teams were assembled, armed with these 2 products, and told to toss them into any sources of standing water that might serve as breeding grounds. Copies of labels and Material Safety Data Sheets were available to give residents if they had questions. Treatment of standing water included both public and private properties. Due to public fears of looters, who were threatened with shooting, EHS teams were appropriately identified with clearly marked MSDH shirts and badges. They were essentially given free reign to treat for mosquitoes anywhere they saw a larval habitat. Extreme situations sometimes require extreme measures. Treating private property for mosquitoes is not ordinarily permitted by state and local laws without an imminent health hazard present. This was a moot point anyway, because after Katrina, distinguishing public lands such as roads from homesites or anything else for that matter was extremely difficult. In worst hit places, the landscape was nothing but a sea of junk and debris with no discernible landmarks. This was precisely why *Bti* and methoprene products were chosen for the larviciding effort—it would be difficult to misuse such products and cause any real harm to people or the environment. Areas larvicided were marked on a large map of the Mississippi Gulf Coast each evening to prevent overtreating and to help plan the next day's work schedule. During the larviciding effort, more than 20,000 mosquito dunks and 4,800 methoprene briquets were applied to a 62 mi^2 area in the 3 coastal counties. Applications were made primarily to roadside ditches, damaged swimming pools, garbage and debris piles with standing water, and any other types of artificial containers holding water (Fig. 2). In addition to the MSDH larviciding efforts, we became aware of other military or FEMA groups also involved in mosquito larviciding. For example, an Emergency Support Function no. 8 team from Florida reported to our incident commander that they had applied more than 1,000 methoprene briquets along the Mississippi Gulf Coast.

Our adult mosquito control effort consisted of surveillance, consultation to local mosquito control agencies, and coordination of control efforts (spraying). By day 11, a team of entomologists (2 from the MSDH and 7 from the CDC) was in place at a local high school that we had commandeered to coordinate vector surveillance and control. Interestingly, a FEMA official asked if there were *anything* else we needed to help with the mosquito control effort, to which we responded, "We want Dr. Bruce Harrison from North Carolina in this state by the end of the week." And he showed up, due to a program called the Emergency Management Assistance Compact, which provides staff and material resources among the states in times of need. The newly formed entomology team ran 15–18 CO_2-baited CDC mosquito traps each night in the 6 lower Mississippi counties (3 counties along the coast, 3 above them) for 2 wk, then weekly for another month. During the next 30 days, we collected a total of 60,533 mosquitoes representing 34 species in 9 genera. The predominant species collected was *Culex nigripalpus* Theobald, making up 71.2% (43,072/60,533) of all mosquitoes trapped and widespread in all counties. Other commonly collected species were *Aedes atlanticus/tormentor* Dyar and Knab and *Psorophora ferox* (von Humboldt). At the time, high numbers of *Culex nigripalpus* were worrisome in light of their vector competence for the West Nile virus (WNV). However, subsequent testing by the CDC of 34,599 mosquitoes from this sample yielded no positives for either WNV or eastern equine encephalitis virus. These results support earlier work posting that there is little evidence of increased disease incidence after natural disasters in the continental US (Nasci and Moore 1998).

In Mississippi, mosquito control is primarily conducted by city or county personnel located within public works or street departments (Edwards et al. 2009), so one of our top priorities was to get these local mosquito entities up and running again. For example, before the storm, the Harrison County Mosquito Control Department had 8 trucks equipped with ultra-low volume spray machines. We worked with their personnel to make sure these trucks were placed back in operation as soon as possible. (There had been considerable damage to their buildings and equipment.) We also helped write "Action Request Forms" for towns and cities requesting FEMA assistance for increased ground spraying in the 6 lower counties. Approximately 2 wk after hurricane landfall, due to increasing mosquito numbers in our CDC light traps, MSDH entomologists requested help from FEMA for an aerial spraying of insecticide in the 3 coastal counties to reduce nuisance mosquito biting on residents (living in partially or totally destroyed dwellings) and responders. FEMA subsequently issued a contract with a private contractor for 1 application of naled. A total of 520,533 acres were sprayed over a 4-night period using 3,050 gallons of insecticide. Results were dramatic: our CDC light trap data showed over 90% control in entire counties in 1 night. No complaints or medical or environmental problems from the increased ground spraying and aerial spraying were reported.

The need for rodent control after the hurricane in Mississippi was minimal (in contrast to New Orleans, where rodent problems were significant). The MSDH coordinated with several private pest control companies to place rodenticides in secured bait stations throughout affected areas. These same private companies were responsible for cleanup and removal of unused baits.

Disasters seem to bring out the best and worst in people. After Katrina, many people saw it as an opportunity for true altruism, while others viewed the disaster as a means of financial gain. Dozens of mosquito control product vendors and salespeople of all types called us almost constantly, offering to "help," which really meant wanting us to purchase products from them. We quickly learned an important lesson—not to make specific pesticide or spraying contractor recommendations. We simply told FEMA and other agencies that we welcomed any FAA-approved aerial spraying contractors and any EPA-registered and properly labeled mosquito control products for use in the response. Political interference was unavoidable. Some salespeople and vendors tried calling their state representatives and senators to try to influence our decisions. One lawyer called us after the contract was issued for spraying with Dibrom® (as mentioned above), insisting that the company he represented be allowed to bid on the aerial spraying project. Not only that, but he also accused us of taking bribes from the other company and threatened legal action against us. Fortunately, the incident commander handled that situation, allowing us to focus on the disaster response.

Overall, the government and private industry response to Hurricane Katrina was deemed a great success. Nuisance mosquito biting, filth fly pests, and rodents were abated using a combination of approaches. In fact, other than aerial spraying for adult mosquitoes, we learned that successful vector control after a hurricane usually could be accomplished without high-tech equipment or chemicals. Old-fashioned techniques of basic sanitation and elimination of pest breeding grounds are critically important, an approach promoted since at least the 1920s (Pierce 1921; Scott 1964). Last, we learned valuable lessons about multiple agency coordination (which can be complex and intimidating) and judicious use of pesticides to protect public health.

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