CASE REPORT

Livestock fatalities attributed to a massive attack of dark rice field mosquitoes (*Psorophora columbiae*) following Hurricane Laura

Bianca S. Cecco,[1] DVM, MSc, DSc; **Emi Sasaki,**[2] DVM, DACVP; **Daniel B. Paulsen,**[2] DVM, PhD, DACVP
Craig Fontenot,[3] DVM; **Christine Navarre,**[4] DVM, MSc, DACVIM; **Kristen Healy,**[5] MSc, PhD, MPH;
***Ingeborg M. Langohr,**[2] DVM, MSc, PhD, DACVP

[1]Setor de Patologia Veterinária, Faculdade de Veterinária, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil, 91540-000
[2]School of Veterinary Medicine, Louisiana State University, Department of Pathobiological Sciences and Louisiana Animal Disease Diagnostic Laboratory, Baton Rouge, LA 70803
[3]Department of Veterinary Clinical Sciences School of Veterinary Medicine, and Agricultural Center Louisiana State University, Baton Rouge, LA 70803
[4]Town & Country Animal Clinic, Ville Platte, LA 70586
[5]Department of Entomology, LSU Agriculture Center, College of Agriculture, Louisiana State University, Baton Rouge, LA 70803
***Corresponding author:** Dr. Ingeborg M. Langohr, imlangohr@gmail.com

Abstract

The objective of this case report is to characterize the sudden fatality of livestock associated with a massive attack of dark rice field mosquitoes *(Psorophora columbiae)* after the passage of Hurricane Laura in southwest Louisiana late August 2020. In 3 days, approximately 30 deer, 600 beef cattle, 100 sheep and 30 horses died following a brief history of weakness or, in most cases, no clinical signs prior to death. Several on-site visits were performed by veterinarians to evaluate animals and perform necropsies. Two deer were received for necropsy, and tissue samples from 1 bull and 1 horse were evaluated at the Louisiana Animal Diagnostic Disease Laboratory. In addition, postmortem examination was performed on another 15 animals by veterinarians. Similar gross alterations were observed in all necropsies. Lesions included multifocal petechiae and ecchymoses in the skin and the subcutaneous tissues. Both deer also had pale discoloration and accentuated lobular patterns in their livers. Histologically, the livers of the deer and the bull exhibited centrilobular degeneration and hepatocyte dissociation suggestive of severe anemia. The description of this animal fatality event associated with *Psorophora columbiae* attack demonstrates the need to establish prevention and/or intervention protocols in areas prone to hurricanes and tropical depressions.

Key words: massive fatalities, cattle, hemorrhage, mosquito, tropical

Introduction

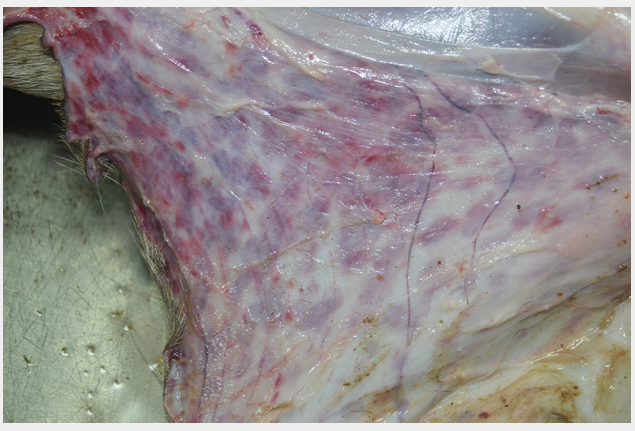
Mosquito control programs have existed in the United States for more than a century, but have been designed primarily to protect human populations from pests and disease-transmitting mosquitoes.[26] Previous studies have demonstrated that mosquitoes can also lead to important economic losses due to decreases in average daily gain and milk production, and animal death.[27] Species of mosquitoes that have been implicated in livestock losses after flooding include *Psorophora columbiae, Aedes sollicitans* and *Aedes taeniorhynchus*.[1,2,6] All of these mosquito species are present in areas susceptible to flooding, including areas where climate instability leads to hurricane formation, such as Louisiana, Florida and Texas.[1,2,6] In recent decades, the incidence and magnitude of natural disasters have grown, resulting in substantial economic damages, with the Gulf Coast commonly affected by such disasters.[18] Although in human medicine, reports of injuries, deaths and the risk of infectious disease outbreaks in the aftermath of natural disasters are common, reports of the loss of livestock as the result of massive mosquito attacks following natural disasters are rare and, except for 1 included in the veterinary literature,[1] are mostly restricted to the entomology literature.[2,6,16,18] Considering the importance of preventive veterinary medicine in relation to natural disasters, we aim to describe the clinical and pathological features of an outbreak of sudden death in livestock due to a massive mosquito attack after the passage of Hurricane Laura in 2020 in Louisiana. We also discuss measures that can be adopted by veterinarians and farm owners in order to prevent economic losses.

Case history

Hurricane Laura made landfall on August 27, 2020, near Cameron, southwest Louisiana (29°47′17″N 93°18′42″W), causing floods, excessive rain and wind in several neighboring parishes.[17] Six to 7 days later, farmers in a five-parish area east and northeast of Cameron reported the death of a large number of cattle and other animal species. The owners also noticed on their properties thick clouds of dark mosquitoes that were surrounding and compelling the animals to be constantly on the move. Some animals were seen covered in mud. In a period of 3 days, approximately 30 deer, 600 beef cattle, 100 sheep, and 30 horses died after a brief history of weakness or, in most cases, without clinical signs prior to death. Animals were from multiple properties and were kept mostly on native or improved Bermuda grass pastures. No reports of human deaths were available. In one of the properties, the owner reported over $100,000 in losses due to cattle deaths.

Two captive deer from the same ranch were sent for postmortem examination to the Louisiana Animal Diagnostic Disease Laboratory (LADDL), 1 was female (A) and the other male (B). Both deer were in good body condition, with moderate to marked postmortem autolysis. One of the deer (deer A) was completely covered in dried mud. No evidence of trauma was observed in either animal. The gross lesions were similar in both animals, although more severe in deer B. The skin and subcutaneous tissues, mainly in the region of the ears and limbs, had multifocal petechiae and ecchymoses (Figure 1). A mosquito was attached to the skin of the right thigh of deer B. The trachea and large bronchi contained moderate amounts of mucoid, pale-yellow fluid mixed with froth. In deer B, a similar mosquito was found mixed with the tracheal contents. The liver had mild (deer A) to moderate (deer B) pale discoloration and a diffusely accentuated lobular pattern (deer B). No other significant gross lesions were observed in the deer. In addition to these 2 deer, selected formalin-fixed tissue samples from 1 bull and 1 horse were received by LADDL; no gross abnormalities were reported. Another 15 animals had field postmortem examinations, and the gross lesions reported were multifocal petechiae and ecchymoses in the skin and subcutaneous tissues.

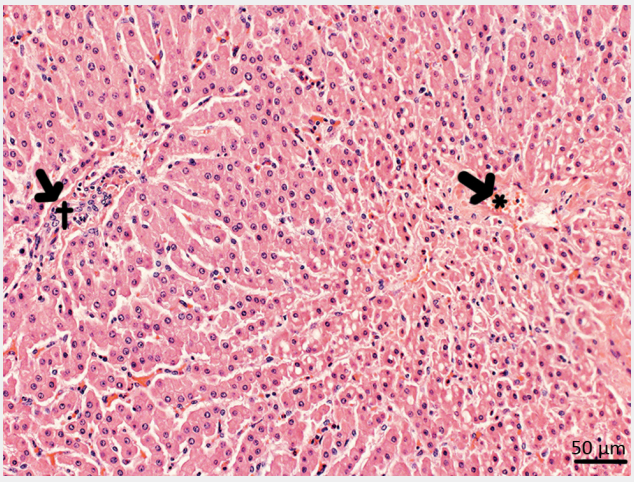
Figure 1: Multifocal to coalescing ecchymotic hemorrhages are present in the subcutaneous tissue of the proximal limb region of deer B submitted for necropsy after a massive attack of dark rice field mosquitoes (*Psorophora columbiae*) following Hurricane Laura in 2020.



Several samples of the major organs of the deer were collected and fixed in 10% neutral buffered formalin. The formalin-fixed tissues were processed for routine histologic evaluation, as per LADDL standard procedures. In both deer, the skin sections collected from the limbs had multifocal, acute, mild, dermal hemorrhages. In deer A, dermal vessels were surrounded by low numbers of lymphocytes, plasma cells and few eosinophils. In deer B, some of the deep dermal vessels had hypertrophic endothelial cells and perivascular mild fibrinous exudate, few neutrophils and rare eosinophils. In deer B, the liver had dissociation of centrilobular to midzonal hepatocytes, and the sinusoids contained reduced numbers of erythrocytes (suggestive of anemia). In the lungs of both deer, the alveoli occasionally contained eosinophilic wispy material (consistent with acute pulmonary edema). In addition, in deer B, the airways had rare foreign material without associated reaction (indicative of terminal aspiration). In the horse, the liver was congested and had mild hepatocellular swelling. The lungs had moderate edema of the interlobular septa and generalized congestion. The spleen was also congested. These lesions were most suggestive of a hypersensitivity/shock reaction. In the bull, the liver had mild to moderate, centrilobular, hepatocellular lipid vacuolation; in addition, centrilobular hepatocytes in some lobules were hypereosinophilic, consistent with degeneration or early necrosis (Figure 2). The lesions in the bull were consistent with hypovolemia, presumably due to exsanguination. Histopathology was not performed for other field necropsies.

No parasites or ova were detected in the deer by fecal floatation and direct microscopic examination. The mosquito attached to the skin of one of the deer submitted for necropsy as well as mosquitoes found on dead cattle in the field were identified as *Psorophora columbiae*.[13] *P. columbiae* was also the

Figure 2: Liver histology of a bull submitted to a field necropsy during the same mosquito-related outbreak as the deer shown in Figure 1. The hepatocytes in the centrilobular region **(asterisk)** have increased cytoplasmic eosinophilia, mild lipid-type vacuolation, and shrunken nuclei indicative of degeneration or early necrosis. For comparison, the hepatocytes surrounding the portal tracts **(cross)** retain their normal architecture, arranged in cords, and their large clear nuclei. Note the relative paucity of red blood cells throughout the sinusoids suggestive of anemia. H&E, bar = 50 µm.



sole mosquito species captured in surveillance traps in the affected area in the initial days following the hurricane and continued to be the prevailing species as is common in the area in the fall (August through October).[a] The local authorities of several parishes established aerial spraying of insecticides (permethrin and bifenthrin) in affected areas, and some owners hired commercial aviators to have their property sprayed. Some groups of animals were kept in barns or stalls with the use of fans to keep the pests away from the animals. Topical insecticides were applied to animals as well. Although cases of sudden death stopped after these measures, veterinarians reported increased incidence of cases of anaplasmosis in animals that survived.

Discussion

Based on epidemiological and clinical data and supported by the gross and microscopic findings, the herein reported deaths of livestock in the immediate aftermath of Hurricane Laura were associated with the attack of mosquitoes, which may have induced severe anemia, exhaustion and hypovolemic shock. Another possibility is that the massive *P. columbiae* attack led to hypersensitivity and shock due to the injection of antigens or toxins by the mosquitoes.[6] Fatalities associated with mosquito attacks have rarely been reported after climate instability, usually caused by the passage of hurricanes that led to flooding in states near the Gulf Coast, such as Texas, Florida and Louisiana.[2] Significant weight loss, decreased milk production, and death of livestock have been attributed to the mosquito's blood-feeding activity. Cattle can also be driven to severe physical fatigue, due to constant movement while trying to escape the insects.[1] Animals search for protection by gathering close together, and those with access to water sources stay in the water up to their heads.[6] One of the deer described here was found covered in mud, presumably as an attempt to protect itself from the mosquito bites.

Species of mosquitoes that have been implicated in livestock losses after flooding include *P. columbiae*, *Aedes sollicitans*, and *Aedes taeniorhynchus*.[1,2,6] All of these mosquito species are present in areas susceptible to flooding in the U.S. and may lead to death by exsanguination. Mosquito identification is, therefore, necessary to determine the causative species. The black fly *Simulium meridionale*, which is prevalent throughout the Mississippi Valley and uses bayous and flooded areas for breeding, has also been implicated in mammalian and avian species losses in Louisiana, named simuliotoxicosis.[22]

P. columbiae, also known as dark rice field mosquito and the mosquito implicated in the herein described livestock mortality, is a member of the broader *Psorophora confinnis* species complex (a group of closely related species) that occurs across much of North and South America.[5] Adults of *P. columbiae* are identified as medium-sized mosquitoes, with a wing length of approximately 4.0 to 4.5 mm.[9,10] The body tends to be dark brown, dark gray or dull black with numerous patches of pale scales.[4,9] The females deposit eggs primarily on the damp soil of open, sunny locations subject to temporary flooding.[7] Thus, quick colonization of temporary pools of water in open, exposed fields or marshes can occur after rainfall events.[30]

P. columbiae is also associated with sun-exposed ephemeral water sources such as pooled water in agricultural lands and disturbed or grassy landscapes.[4,5] Rain within a preceding two-week period, or high precipitation, and lack of canopy cover over standing water are strongly associated with the rapid population growth of *P. columbiae*.[7] Therefore, hurricanes produce ideal conditions for the proliferation of *P. columbiae* because they not only provide large rain events, they also strip leaves from the trees, exposing the standing water to sunlight. Dark rice field mosquitoes have been described as preferring to take blood meals from large mammalian hosts, particularly livestock such as cattle.[19] Livestock species and rabbits are well-recognized hosts of this mosquito; blood meal analysis in Florida showed that *P. columbiae* blood meals were taken most commonly from rabbits (40%) and cattle (37%).[13]

Large numbers of *P. columbiae* have historically contributed to suffocation and anemia.[6,16] When the cause of death is related to anemia due to the mosquitoes feeding on the animals' blood, the main histological finding is hepatic centrilobular necrosis. In one of the 2 deer submitted for necropsy in this mortality event, and in the bull sample, the liver had centrilobular hepatocyte dissociation and vacuolar degeneration, in addition to reduced red blood cells, suggestive of anemia due to acute blood loss. Death may also be associated with extreme fatigue (exhaustion) since animals keep walking and moving continuously to escape from the insects.[6] Some reports identified suffocation as an additional possible cause of death.[2] One of the deer submitted for necropsy in our case had 1 mosquito in the tracheal lumen, suggesting that, in cases in which more insects are seen in the airways, suffocation may be a possibility. The most consistent feature observed in our cases was the presence of petechiae and ecchymoses on the skin and subcutaneous tissue of limbs and ears. This feature is similar to what is described for simuliotoxicosis in poultry, in which the gross lesions consist of dermal hemorrhage and edema.[25] Histologically, both insects can cause eosinophilic dermatitis. Differential diagnoses for the sudden death of a large number of animals include toxic agents, including organophosphates or carbamates; however, herd history and access to this type of agents were excluded by the field veterinarians' on-site visits.

P. columbiae has been linked to the transmission of several pathogens, including West Nile Virus,[15,24,29] Venezuelan equine encephalitis virus[22] and Rift Valley Fever virus.[28] Additionally, *P. columbiae* can carry infective stages of canine heartworm, *Dirofilaria immitis*, and, since *P. columbiae* can be very abundant after large rainfall events, it has been incriminated as a significant heartworm vector.[20,23] In our case, field veterinarians anecdotally noticed an increased incidence of cases of anaplasmosis for which the mosquito may have functioned as a mechanical vector.

Strategies to prevent and manage massive mosquito attacks are needed to protect the welfare of livestock. Systematic disaster response for animals requires continual development and improvement.[12] During disasters, such as major storm systems, including hurricanes, excessive rain and wind, ephemeral water pools capable of supporting floodwater mosquitoes can be too widespread to manage with point-source treatments alone.[8] Therefore, interventions such as aerial larvicide and adulticide applications, as was done in this case, should be considered.[3,8] One potential responder for disasters is the Aerial Spray Flight of the United States Air Force Reserve, which can provide aerial applications of mosquito adulticides to suppress mosquito and filth fly populations in Louisiana and Texas, following natural disasters such as Hurricane Laura.[8] Such effective methods can have a positive outcome on the health and well-being of local residents and are also considered an important asset in public health mosquito

control as well.[8] Appropriate surveillance measures to assess the need for aerial insecticide intervention and follow-up measures for the evaluation of the effectiveness of aerial applications need to be developed and applied prior to mass death events.[8] Other tools recommended to minimize the contact of biting mosquitoes are mass collection traps and topical skin repellents. Alternative approaches include the deployment of stationary tools and portable emanators that deliver spatial repellents to prevent mosquito bites in a limited area and thereby provide a "safe zone" for animal survival.[6,11]

Conclusions

In summary, at the beginning of September 2020, massive swarms of *P. columbiae* caused significant mortality in approximately 800 livestock. The outbreak occurred 6 to 7 days after the landfall of Hurricane Laura, which caused severe flooding, excessive rain and extensive stripping of the tree canopy in Southwest Louisiana. The livestock loss caused significant economic losses related to animal deaths and production loss. Four to 5 days after the first livestock deaths, following the determination that the mosquito swarms were the probable cause, the local authorities established aerial spraying of insecticides in affected areas and some individuals hired planes to have their property sprayed. Fans to keep away any insect swarms were employed. Similar animal disasters should be anticipated following widespread wind and rain events, such as hurricane landfall in the Gulf Coast areas. Surveillance plans and effective control measures need to be developed and employed appropriately to prevent massive livestock deaths and potential human health problems prior to future similar weather events.

Author contributions

BSC, ES, DBP, CF, CN, IML received and diagnosed the cases. KH assisted with the mosquito identification. BSC wrote the manuscript. ES, DBP, CF, CN, KH, and IML contributed also to the review and editing of the manuscript. All authors read and approved the manuscript.

Endnote

[a]Heath Deese, Jefferson Davis Parish Mosquito Abatement District # 1, Jennings, LA 70546 (personal communication, March 2022).

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