

be expanding. Several disease patterns exist and range from unapparent acute, and/or chronic lesions. Deer herds in infection to various combinations of peracute, the southeastern coastal plains, south Florida, and Texas consistently have antibodies to multiple EHDV and BTV serotypes, indicating a high rate of previous viral infection; however, clinical disease in these regions is rare. Abundant midge populations probably facilitate annual virus activity resulting in constant herd immunity and protection from disease. Deer in more northerly states experience hemorrhagic disease sporadically, but outbreaks are more severe with higher mortality. The EHDV and BTV may not be able to continually persist in these regions because the midge species present are inefficient vectors or generally are not very abundant. Following an outbreak, herd immunity declines over time if there is no further virus activity, and subsequent outbreaks occur as virus spreads into non-immune deer populations. A general rule for the eastern half of the United States and the Midwest is that as latitude increases (to the North), the frequency of infection and number of disease outbreaks decrease, but the severity of clinical disease and the likelihood of significant mortality increase. Possible explanations for this regional pattern of disease include maternal protective immunity, acquired immunity from previous infections with similar serotypes of EHDV or BTV, and innate resistance of some subspecies (or regional populations) of deer to clinical disease.

Impact of Hemorrhagic Disease on Deer Populations

The severity and distribution of hemorrhagic disease are highly variable. Past occurrences have ranged from a few scattered mild cases to dramatic outbreaks. Death losses during outbreaks usually are well below 25 percent of the population, but in a few instances have been 50 percent or more. To date, repeated HD outbreaks have not represented a limiting factor to deer population growth. There is little or no evidence to suggest that outbreak severity is related to population density.



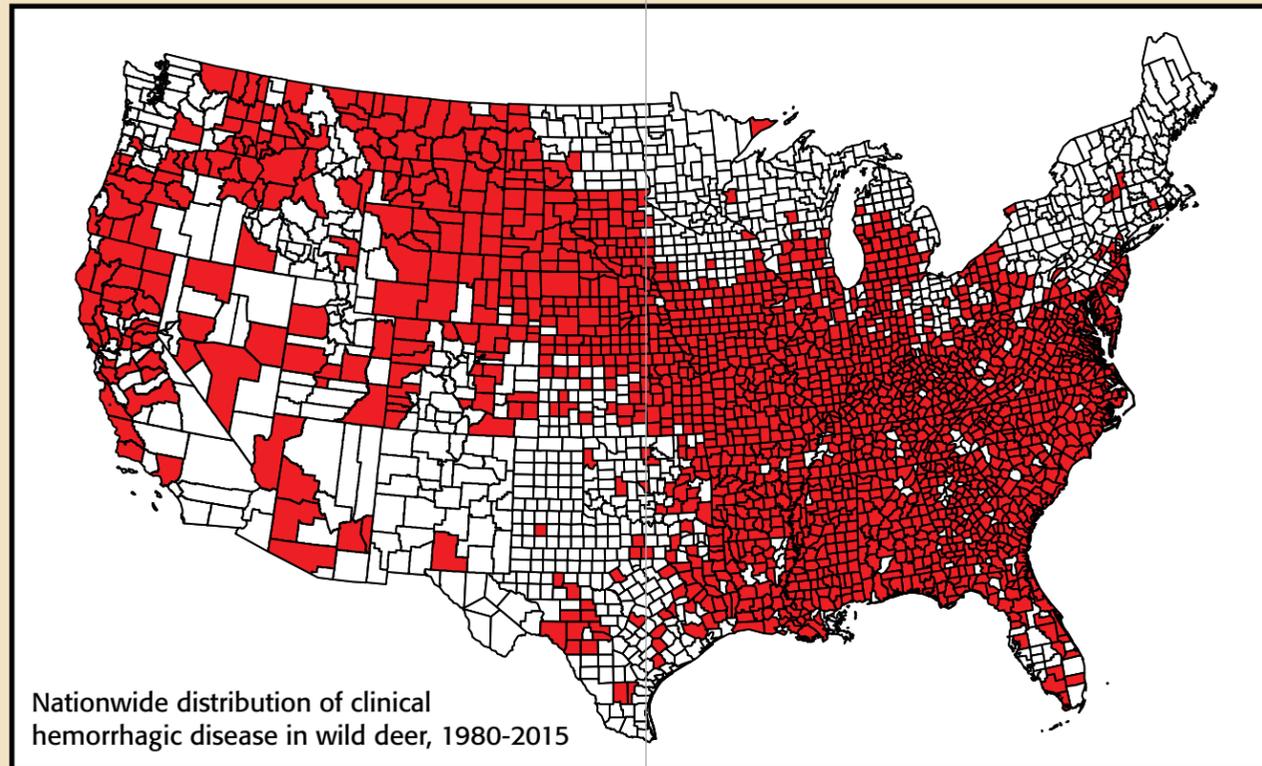
Adult female biting midge feeding upon a laboratory rabbit. Hemorrhagic disease viruses are spread by these small flies. (Photo: Charles McKinnon, USDA)

Diagnosis of Hemorrhagic Disease

A strong tentative diagnosis can be made on the basis of history and presentation, combined with field necropsy and observation of lesions. A confirmed diagnosis of EHDV or BTV infection requires virus isolation or polymerase chain reaction (PCR) detection of viral nucleic acids. The preferred specimens for virus isolation or PCR are refrigerated whole blood in anticoagulant and refrigerated spleen, lymph node, and lung from a fresh carcass. Contact the diagnostic laboratory prior to shipping the sample in order to obtain advice on collection and shipment of specimens.

Human Health Implications

These viruses do not infect humans, and humans are not at risk by handling infected deer, eating venison from infected deer, or being bitten by *Culicoides* vectors. Deer with generalized disease are not suitable for consumption.



Livestock Implications

Past observations have revealed that simultaneous infections sometimes occur in deer, cattle, and sheep. If the vector and virus are present in the vicinity, deer and livestock are at risk of infection. While the significance of EHDV and BTV to white-tailed deer is established, the importance of these agents to domestic livestock is more difficult to assess. Most BTV infections in cattle are subclinical; however, a small percentage of animals can develop fever, lameness, sore mouths, and reproductive problems. Less is known about EHDV in cattle. EHDV has been isolated from sick cattle, and surveys have shown that cattle often have antibodies to this virus, indicating frequent exposure. Domestic sheep are generally unaffected by EHDV, but BTV can cause severe disease similar to that in deer. Hemorrhagic disease can have severe impacts in captive white-tailed deer, especially in animals translocated from northern to

endemic areas in the southern United States. Vaccines are not currently available and have not been tested in white-tailed deer.

Control and Prevention of Hemorrhagic Disease

At present, there are no wildlife management tools or strategies available to prevent or control hemorrhagic disease. Although die-offs of whitetails due to hemorrhagic disease often cause alarm, past experiences have shown that mortality will not decimate local deer populations and that the outbreak will be curtailed by the onset of cold weather. Livestock owners who suspect EHDV or BTV infections should seek veterinary assistance to get disease diagnostics and supportive care for their animals.

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Hemorrhagic Disease of White-tailed Deer



Hemorrhagic disease (HD) is the most important viral disease of white-tailed deer in the United States, and occurs over a large part of the country, although the frequency and severity of outbreaks vary regionally. The disease is caused by related orbiviruses (Reoviridae) in the epizootic hemorrhagic disease (EHD) and bluetongue (BT) virus serogroups. Because clinical disease produced by EHD and BT viruses is indistinguishable, the general term "hemorrhagic disease" often is used when the specific causative virus is unknown. The EHD and BT viruses are transmitted by biting flies, and HD occurs seasonally in late summer and fall (approximately late July through November).

Causative Agents

Deer die-offs consistent with HD were noted as early as 1886, and EHD virus (EHDV) and BT virus (BTV) isolations from infected deer were first reported in 1955 and 1968, respectively. Prior to 2004, only two subtypes of EHDV (EHDV-1 and 2) and five subtypes of BTV (2, 10, 11, 13, 17) were known to be present in North America. However, multiple EHDV and BTV subtypes have been associated with HD more recently and one subtype in particular, EHDV-6, continues to be detected regularly during HD outbreaks in deer.

The Vectors

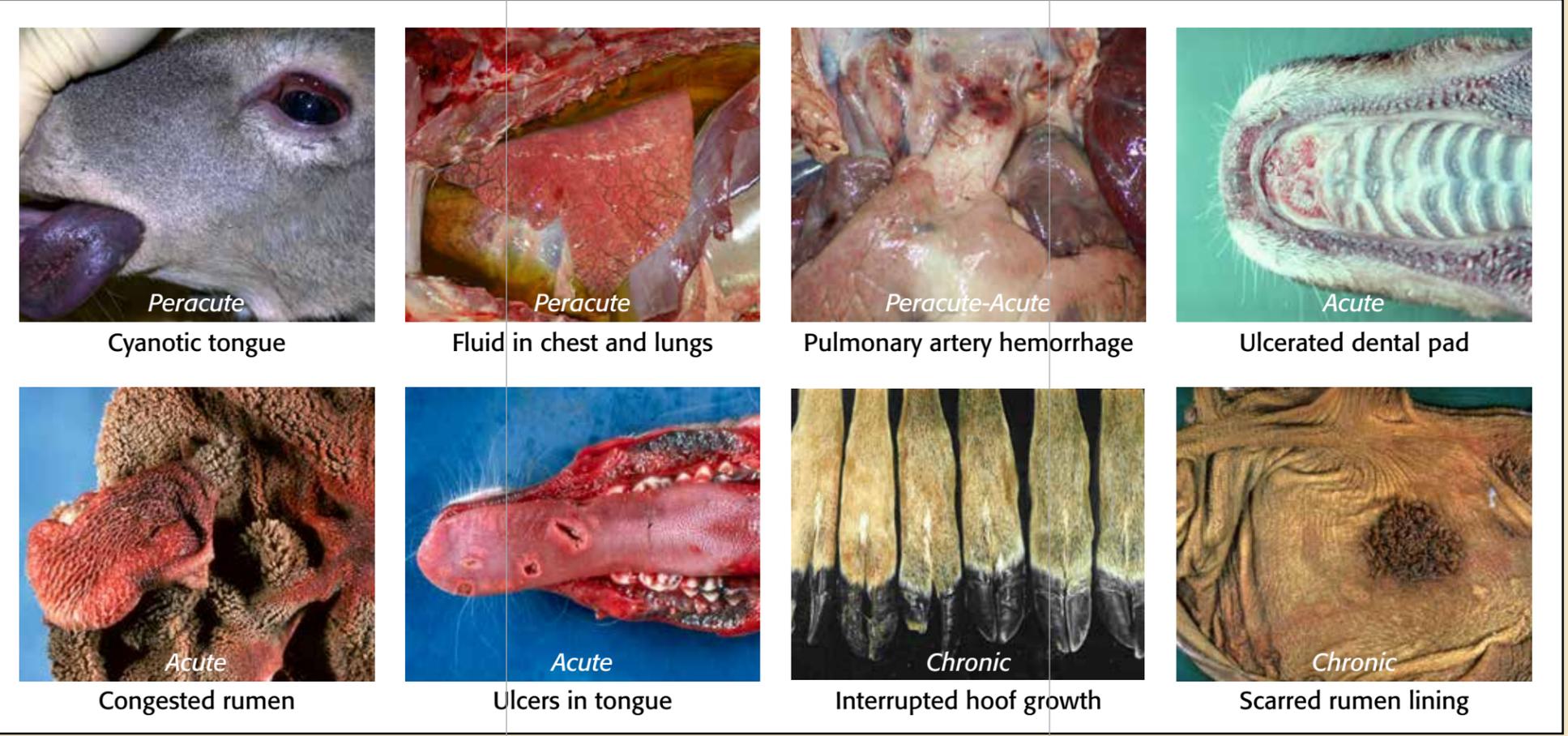
The viruses that cause HD are transmitted by biting flies in the genus *Culicoides*. The best documented vector in North America is *Culicoides sonorensis* although other *Culicoides* species may play a role in local transmission in certain regions, such as *C. insignis* along the Gulf Coast. These flies are commonly known as biting midges but also are called sand gnats, sand flies, no-see-ums, and punkies. The seasonal occurrence of hemorrhagic disease coincides with periods of biting midge abundance. The onset of freezing temperatures in late fall affects vector populations and usually

brings a sudden end to hemorrhagic disease outbreaks. How the viruses persist through the winter when midges are not active is not clear. However, it is believed that in areas with a mild climate, vector populations may remain active and locally support year-round virus transmission.

Susceptible Wildlife Hosts

Although EHDV and BTV are infectious to a wide range of wild ruminants, susceptibility varies among species. Clinical disease due to EHDV has been reported in white-tailed deer, mule deer, bighorn sheep, elk, and pronghorn, and clinical disease due to BTV has been reported in these species, as well as in black-tailed deer. Infections in these wild ruminants can range from mild or no disease to episodes of high mortality. Antibodies or virus also have been detected in bison and mountain goats; however, these infections were not associated with disease. In the Southeast, mild infections in white-tailed deer are common and are evidenced only by antibodies to the viruses in serum of normal, healthy deer.

Lesions of Hemorrhagic Disease



Important Questions Concerning Hemorrhagic Disease in Deer

What are the Clinical Signs and Lesions of Hemorrhagic Disease?

Clinical signs of infection are highly variable and many infected deer appear normal or show only mild signs of illness. When illness occurs, signs and lesions change as the disease progresses. Initially, animals may be depressed and feverish, with a swollen head, neck, tongue, or eyelids, and breathing difficulty. Deer may

die within 1 to 3 days. More often, deer survive longer and may become lame, lose their appetite, or reduce their activity. A smaller proportion of infected animals may be disabled for weeks or months by lameness and emaciation. Lesions, as with outward signs, can be quite variable in deer depending on the immune status of the host and duration of infection. The development of different lesions as the disease progresses has led to categorization of 3 "forms" of hemorrhagic disease: peracute, acute, and chronic. The peracute, or very rapid form, shows only severe fluid swelling (edema) of the head, neck, tongue, eyelids, and lungs. In animals living

somewhat longer, the acute or "classic hemorrhagic" form occurs. These animals may have edema in the same locations but also have hemorrhages or congestion in the heart, pulmonary artery, oral mucosa, rumen, abomasum, or intestines. There may be erosions or ulcerations on the dental pad, tongue, palate, rumen, omasum, and abomasum. The chronic form is typified by growth interruptions of the hooves and possible sloughing of the hoof walls. Other chronic lesions include oral ulcerations, papillae loss and scarring of rumen mucosa, emaciation during the winter, and rarely, antler malformations. It should be emphasized that all

of the above lesions will not be found in an individual deer, and other diseases also produce similar edematous, hemorrhagic, or ulcerative lesions.

When Should You Suspect Hemorrhagic Disease?

Hemorrhagic disease should be suspected in instances of unexplained deer mortality during late summer or early fall, especially if any of the characteristic signs or lesions are noted. An easy lesion to see in the field is the erosion or ulceration of the dental pad. Because deer have a high fever and are dehydrated, they often are found near water. Sick or dead deer should be reported promptly to state wildlife agency personnel because other native diseases and some foreign diseases resemble hemorrhagic disease. Also, prompt notification and submission of the carcass will facilitate diagnostic procedures. If hunter-harvested deer have growth interruptions in their hooves or chronic lesions of the rumen lining, previous exposure to EHDV or BTV can be suspected. However, virus is no longer present in deer with chronic lesions and virus isolation is not possible. Tests for antibodies in hunter-harvested deer serum may be used to estimate previous EHDV or BTV activity in a herd.

Where Do EHDV/BTV Infections and Hemorrhagic Disease Occur?

Infection refers to the invasion and multiplication of the virus in deer or other ruminants, while disease refers to the production of noticeable clinical signs. The national distribution of hemorrhagic disease outbreaks in white-tailed deer from 1980-2015 is shown on the map. Monitoring natural outbreaks of hemorrhagic disease over the last thirty-plus years has shown that infection of white-tailed deer with EHDV and BTV is much more common and geographically widespread than clinical disease. More recently, the geographic range appears to