Susceptibility of North American wild ungulates to foot-and-mouth disease virus: initial findings

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Abstract:

The only known occurrence of foot-and-mouth disease in wildlife in the United States occurred in 1924 when the infection was transmitted from cattle to mule deer (Odocoileus hemionus) sharing common pasture. In an experimental infection in the 1970’s, white-tailed deer (Odocoileus virginianus) were susceptible to infection and capable transmitters of the virus to cattle. The susceptibility and transmission capability of other wild North American ungulates are unknown. This report provides preliminary results of experimental infections of North American bison (Bison bison), elk (Cervus elaphus nelsoni), pronghorn (Antilocapra americana) and mule deer.

A total of 6 bison, 8 elk, 12 pronghorn, 14 mule deer, and 20 cattle were included in a series of experiments conducted at Plum Island Animal Disease Center (PIADC), New York, USA. Following intraepithelial tongue inoculation with O1 Manisa FMD virus, disease development was monitored in inoculated and contact animals. Intra and interspecies transmission studies were conducted between the wildlife species and cattle. Specimens were collected throughout the studies for routine laboratory testing including serology, virus isolation, and PCR. Animals were euthanized, followed by necropsy and histopathology.

Clinical disease occurred in all inoculated animals as well as all contact-exposed bison, pronghorn, and mule deer. Clinical disease, however, did not occur in contact-exposed elk or in cattle exposed to inoculated elk. Only one contact elk showed serologic evidence of FMD virus infection. Lesions affected oral cavities and feet of all species. Oral lesions were mild in pronghorn and elk, and severe in bison cattle, and mule deer. Foot lesions were mild in elk and severe in the other species. Myocarditis was seen in the bison and mule deer. Intra and interspecies transmission occurred in all species except elk. Results of these studies indicate the susceptibility and transmission capability of three of the four wild ungulate species examined. Additionally, the severity of lesions in these species suggests that in a natural outbreak, mortality could be high. Results also indicate some resistance of elk to transmission and severe clinical signs from O1 Manisa. Further studies to evaluate vaccine efficacy in bison and white-tailed deer are planned.

Introduction:

An outbreak of foot-and-mouth disease has only occurred once in wildlife in the United States. That occurrence was in 1924 when the infection was transmitted from cattle to mule deer sharing common pasture in the Stanislaus National Forrest in California (Keane, 1927). In the 1970’s, experimentally-infected white-tailed deer were shown to be susceptible to infection and capable transmitters of the virus to cattle (McVicar et al., 1974). Little information is available on the susceptibility and transmission capability of other wild North American ungulates. Natural infection has occurred in European bison (Bison bonasus) (Folmer, 1939; Jaczewski, 1959; Jaczewski, 1960; Podgurniak, 1967), North American bison (Folmer, 1939; Hediger, 1940), and hybrids (Bison bonasus X Bison bison) (Folmer, 1939) in European zoos; however, the reports of FMD in North American bison are little more than anecdotes. Naturally occurring (Cohrs and Weber-Springe, 1939) and experimental infection (Forman and Gibbs, 1974; Forman et al., 1974; Gibbs et al., 1975) of foot-and-mouth disease in red deer (Cervus elaphus elaphus) have been reported. We have found no reports of FMD in North America.
American elk or pronghorn. This report provides preliminary results of experimental infections of North American bison, elk, pronghorn, and mule deer.

Materials and Methods:

In all species, animals received intraepithelial tongue and intramuscular inoculation with O1 Manisa FMD virus. The inoculating dose used in all species was 10,000 bovine tongue infective doses (BTID). Concurrent with inoculation of the wildlife species in each study, one bovine steer was inoculated and exposed to a contact steer. When clinical evidence of FMD was observed in the contact-exposed wildlife and cattle, these animals were moved to rooms containing unexposed cattle and wildlife for inter and intraspecies transmission studies. In the bison study, cattle were exposed to FMDV infected bison 5 days after the bison developed clinical signs of disease due to logistical reasons. In all other studies, infected and contact animals were placed together immediately following development of clinical signs of FMD.

Following inoculation and exposure, disease development was monitored in inoculated and contact animals. Specimens were collected throughout the studies for routine laboratory testing including serology, virus isolation, and PCR. At various time points throughout the studies, animals were euthanized followed by necropsy and histopathology. Numbers of animals inoculated and contact-exposed (Table 1) varied between experiments.

Table 1. Numbers of inoculated and contact-exposed wildlife and cattle in the experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Inoc Cattle</th>
<th>Inoc Wildlife</th>
<th>Contact Cattle</th>
<th>Contact Wildlife</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bison</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Elk</td>
<td>1</td>
<td>3*</td>
<td>3</td>
<td>6*</td>
</tr>
<tr>
<td>Pronghorn</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Mule Deer</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

*One elk was contact-exposed and later inoculated.

Results:

Clinical evidence of FMD infection occurred in all inoculated wildlife and cattle and in all contact-exposed bison, pronghorn, and mule deer. Clinical disease, however, did not occur in animals in contact with either inoculated or contact-exposed elk. Neither did clinical disease occur in elk exposed to FMD-infected cattle. Cattle exposed to infected pronghorn and mule deer developed disease. Two cattle exposed to bison 5 days after the bison developed clinical signs of FMDV infection failed to develop disease.

Bison routinely developed fever, lameness, inappetence, chewing movements, and ptyalism. Physical examination revealed numerous small vesicles and erosions affecting tongue, gingiva, muzzle, coronary bands, and interdigital skin. Inoculated elk developed transient fever, minimal ptyalism, mild lameness, and mild tongue and foot lesions. Pronghorn and mule deer were similar in clinical signs which included fever, depression, transient inappetence, and severe lameness. One difference in deer and pronghorn was that pronghorn developed only minimal oral lesions whereas mule deer acutely developed numerous small oral vesicles particularly on the dorsal surface of the tongue. These rapidly progressed to erosions and subsequently healed.

At necropsy, lesions affected oral cavities and feet of all species. Oral lesions were mild in pronghorn and elk, and severe in bison cattle, and mule deer. Foot lesions were mild in elk and severe in the other species. Myocarditis was seen in the bison and mule deer. Ulcers were noted on the pillars of the rumen in one or more animals from each species. Histopathologic findings in bison, elk, and pronghorn were typical of FMD lesions in domestic species consisting acutely of vesicles progressing to erosions. In time, erosions healed or, in some cases, ulcerated. In animals of all species necropsied 6 weeks post inoculation or exposure, oral lesions were healed. Chronic foot lesions occurred in all species and usually consisted of concentric hoof wall deformities. Histopathologic and microbiologic results for mule deer are pending.
Clinical evidence of intra and interspecies transmission occurred in all species except elk. Laboratory evidence of FMDV infection (virus isolation, PCR, or detection of 3ABC nonstructural protein) was found in all inoculated bison, elk, pronghorn, and cattle and in all contact-exposed bison, and pronghorn. Only one contact-exposed elk developed antibody to virus nonstructural protein (3ABC) serving as serologic evidence of FMD virus infection. Although bison exposed to FMDV-infected bison contracted FMD, 2 cattle exposed later to infected bison developed neither clinical nor laboratory evidence of infection. FMD virus was not isolated from tissues or oropharyngeal fluids of bison, elk, or pronghorn past 28 days post inoculation or exposure.

Discussion:

Results of these studies indicate the susceptibility and transmission capability of three of the four wild ungulate species examined. Interspecies infection between wildlife and cattle occurred with all species except elk. The failure of 2 cattle to develop FMD after contact with infected bison is likely due to the late exposure which missed the initial period of intense virus shedding.

The severity of lesions in bison, pronghorn and mule deer suggests that in a natural outbreak, mortality could be high due to lameness resulting in increased predation. Such was the case in natural outbreaks of FMD in European bison in preserves (Podgurniak, 1967) and in mule deer in California (Keane, 1927). Results also indicate some resistance of elk to transmission and severe clinical signs from O1 Manisa infection. These results are consistent with findings in experimentally-infected conspecific red deer (Gibbs et al., 1975). Further studies to evaluate vaccine efficacy in bison and white-tailed deer are planned.

Authors’ Conclusions:

- Bison, pronghorn, and mule deer, but not elk are highly susceptible to O1 Manisa FMDV infection.
- In nature, FMD infection in bison, pronghorn and mule deer would likely result in significant mortality.
- The findings are limited due to the small sample size of these experiments.

Authors’ Recommendation:

- Vaccine development applicable to wildlife is needed.

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References:


