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Authors: Nyamsuren, D., Joly, Damien O., Enkhtuvshin, S., Odonkhuu, D., Olson, Kirk A., et al.

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Exposure of Mongolian gazelles (*Procapra gutturosa*) to foot and mouth disease virus

D. Nyamsuren,[1] **Damien O. Joly,**[2,7] **S. Enkhtuvshin,**[3] **D. Odonkhuu,**[4] **Kirk A. Olson,**[5] **Matthys Draisma,**[6] **and William B. Karesh**[2] [1] Dornod Aimag Veterinarian Center, Choibalsan, Dornod Aimag, Mongolia; [2] Field Veterinary Program, Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York, USA; [3] Western Institute for Food Safety and Security, University of California, Davis, 1 Shields Avenue, Davis, California, USA; [4] Department of Ecology, Faculty of Biology, National University of Mongolia, Ulaanbaatar, Mongolia; [5] Wildlife Conservation Society, Choibalsan, Dornod Aimag, Mongolia; [6] 83 Stoddart's Road, Warragul, Victoria 3820, Australia; [7] Currrent Address: Fish and Wildlife Division, Alberta Sustainable Resource Development, 6909 116 Street, Edmonton, Alberta T6H 4P2, Canada; [8] (Corresponding author: email: dojoly@gmail.com)

ABSTRACT: Foot and mouth disease is a highly contagious acute viral disease that affects most ruminant and porcine species. During 2001, 33 serum samples were collected from Mongolian gazelles (*Procapra gutturosa*) in the Eastern Steppe of Mongolia. Samples were tested for antibodies to seven subtypes of foot-and-mouth-disease virus (FMDV). Antibodies were detected in 67% of the animals, and serologic results indicated exposure to FMDV-O. This virus was present in domestic animal populations in Mongolia from 2000 to 2002, and it is likely that the antibodies to FMDV detected in these gazelles resulted from spillover of virus from domestic animal sources.

Key words: Foot and mouth disease, Mongolian gazelle, *Procapra gutturosa*.

INTRODUCTION

The Mongolian gazelle (*Procapra gutturosa*) is one of the few remaining species that maintains a long-distance migration in large numbers (Berger, 2004). In 1950, Mongolian gazelles ranged across a 780,000 km^2 area bordered by Kazakhstan, the Russian Federation, and China (Lhagvasuren and Milner-Gulland, 1997). However, the current range of the gazelle encompasses only about 25–30% of this area; disease outbreaks, legal and illegal hunting, habitat conversion, and severe winters are thought to have been responsible for this decline in abundance and range contraction (Lhagvasuren and Milner-Gulland, 1997; Wang et al., 1997; Schaller and Lhagvasuren, 1998). Mongolian gazelles can still be found in high numbers and may still number one million in Eastern Mongolia (Olson et al., 2005).

Foot and mouth disease (FMD), which can be caused by seven subtypes of foot-and-mouth-disease virus (FMDV), is a highly contagious disease of cloven-hoofed species that causes vesicular lesions or blisters associated with the oral cavity, coronary bands of the hoof, interdigital skin, and the udder (Thomson et al., 2001). Livestock may experience fever, anorexia, excessive salivation, nasal discharge, and lameness. Infection with FMDV can result in weight loss, poor milk production, with resultant secondary bacterial infections, mastitis, abortion, and possibly death. The disease is highly transmissible by contact with both live animals or by contact with bodily excretions such as feces, urine, milk, and saliva from affected animals. It spreads rapidly in susceptible populations and causes high losses due to diminished productivity and restricted meat and livestock trade (Thomson et al., 2001). The degree of severity varies among species and with the FMDV; disease effects can range from no clinical signs (African Buffalo, *Syncerus caffer*) to relatively high case-fatality rates (>50% in mountain gazelles, *Gazella gazella* in Israel; Shimshoney et al., 1986; Thomson et al. 2001, 2003).

In the early 1960s, an outbreak of FMDV killed large numbers of gazelles in Mongolia's Eastern Steppe (Sokolov and Lushchekina, 1997). According to Mongolian government records, FMDV outbreaks occurred in domestic livestock intermittently from 1931 to 1973 (FMDV-A and FMDV-O), and then not again until 2000–2002 and 2004 (FMDV-O). Sub-

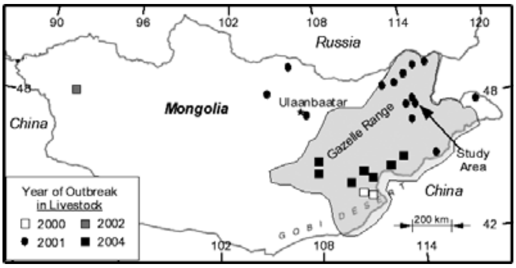

FIGURE 1. Location of recent foot-and-mouth-disease virus (FMDV) outbreaks in Mongolia and the current study area. Locations for livestock outbreaks are from Sodnomdarjaa (2005) and the gazelle range is modified from Lhagvasuren and Milner-Gulland (1997).

sequent to this study, an outbreak of FMDV-Asia1 occurred in livestock (Mongolian official report to the Office International des Épizooties, URL: http://www.oie.int/eng/info/hebdo/AIS_56.HTM#Sec9). There were no reports of mortality or morbidity among gazelles in the 2000–2002 outbreaks, although gazelles with clinical signs were observed in the 2004 outbreak (6/52 gazelles examined; Sodnomdarjaa, 2005). The distribution of recent outbreaks is shown in Figure 1. Throughout their range (Fig. 1), gazelles occupy habitats that are also used by susceptible domestic stock, including sheep, goats, bactrian camels, and cows; because of this overlap, there has been concern that gazelles and other wildlife species may be an effective means for the spread of FMDV.

The presence of FMDV on the Eastern Steppe forms two critical threats to the conservation of gazelles (WCS, 2003). First, attempts to manage FMDV outbreaks in domestic livestock may have negative effects on gazelle ecology because actions taken to control FMDV often include culling of wildlife and/or erection of fences to limit movement (Hall, 1927; Anonymous, 1948; Bruckner et al., 2002). As gazelles are blamed for spreading FMDV to domestic livestock; there may be increased calls for culling of gazelles or disruption of their seasonal migration patterns through fencing. Gazelles are able to exist in such a low-productivity, highly seasonal environment by migrating to new food sources (Leimgruber et al., 2001); thus, disruption of this migration may lead to catastrophic mortality events. Culling is also a poor option, as gazelles are a valuable subsistence resource for local people (Zahler et al., 2004). Second, FMDV has the potential to directly exacerbate the long-term decline in gazelle abundance by causing significant mortality as recorded in the 1960s.

Understanding the role of gazelles in FMDV epidemiology on the Mongolian Eastern Steppe is critical to developing effective FMDV strategies. Mongolian gazelles may be passive recipients of FMDV spilling over from domestic livestock or they may actively maintain the virus and transmit it to livestock. Herein, we provide data from a serological survey for FMDV in gazelles in November 2001. Our objective was to determine whether gazelles had been exposed to FMDV during a concurrent outbreak in livestock. To provide context, we also discuss data from a previously published serological survey for FMDV in gazelles conducted during 1998/1999 (Deem et al., 2001).

In November 2001, sera were collected from gazelles harvested during a pilot program to investigate and demonstrate improved sanitary handling of carcasses for future commercial harvesting of gazelle (Zahler et al., 2004). All gazelles were harvested on the Eastern Steppe, in the vicinity of 48°N, 114°E (Fig. 1). Blood was drawn directly from the heart immediately after each animal was shot and located. Samples were kept just above freezing and upright overnight to allow proper clot formation before sera were drawn and stored frozen in sealed Nalgene tubes. Field conditions were primitive and electric centrifuge and refrigeration were unavailable. Sex was recorded and age was determined by counting cementum annuli of the front incisor (Matson's Laboratory, LLC; Milltown, Montana, USA).

Gazelle sera were analyzed at the Foreign Animal Disease Diagnostic Laboratory, Plum Island Animal Disease Center (United States Department of Agriculture) for serological testing for FMDV strains using virus neutralization (details of the methodology available at URL:http://www.oie.int/eng/normes/mmanual/A_00024.htm; OIE, 2004). Sera were tested for seven FMDV serotypes.

We tested for an influence of age on FMDV exposure by testing for a difference in average age between FMDV antibody-positive and FMDV antibody-negative gazelles using a *t*-test. We compared FMDV seroprevalence between males and females using a chi-square test, using a simulated *P*-value to buffer against the effect of low sample sizes (program R v 1.9.1; R Development Core Team, 2004).

Suitable sera for FMDV antibody testing were available from 33 gazelles (28 females, 5 males, average age 3.06 yr, SE 1.9 yr, minimum age 1 yr). Twenty-two gazelles were seropositive for FMDV-O, resulting in an estimated seroprevalence of 67% (95% confidence interval 48–82%). Antibody titers for type O among seropositive gazelles ranged from 34 to 320. Of these 22 seropositive gazelles, six gazelles also tested positive for other subtypes, but at significantly lower titers: FMDV-Asia1 ($n=2$, titers 20 and 24 vs. 110 and 270, respectively, for type O), FMDV-C ($n=1$, titer 24 vs. 270 for type O), and FMD-SAT ($n=3$, titers 20, 24, and 24 vs. 57, 80, and 48, respectively, for type O). In light of the concurrent outbreak of FMDV-O in sympatric domestic livestock (Enkhtuvshin, 2004) and the absence of other strains during the outbreak, we interpret these findings as indicating these gazelles had been exposed to FMDV-O. Consequently, we estimated seroprevalence to be 67% (22/33, 95% confidence interval 48–82%). The average age did not differ between positive (average age=3.09 yr, SD=2.18) and negative (average age=3.0 yr, SD=1.15) gazelles ($t=0.154$, df=29, $P=0.88$). Exposure rate did not differ between male (4/5 serologically positive) and female (18/28 serologically positive) gazelles (simulated $\chi^2=0.47$, $P=0.305$). No clinical signs were observed.

The role of the Mongolian gazelle in the epidemiology of FMDV in Mongolia is unknown. However, considering the chronology of FMDV-related events in Mongolia may provide some insight. FMDV was not present in livestock between the 1973 and the outbreak in livestock in 2000 (Enkhtuvshin, 2004). Further, none of 59 gazelles tested in the current study area in 1998/99 were seropositive (Deem et al., 2001). Assuming that gazelles exist in one panmictic population (a reasonable assumption given the large migrations of gazelles and highly infectious nature of FMDV), no positives from a sample of 59 indicates that, if FMDV was present, its seroprevalence was less than 6% (upper 95% confidence limit for 0/59). When FMDV has been present in gazelle populations, seroprevalence of FMDV easily exceeded 50% (e.g., this study; Sodnomdarjaa, 2005); thus, it is unlikely that FMDV was present at the time of the surveys in 1998/99 but was undetected. However, following the outbreak in domestic livestock in the winter of 2001, we showed that a large proportion of gazelles that were tested showed evidence of exposure. Thus, we might surmise that gazelles are passive recipients of FMDV from livestock: FMDV presence in livestock is necessary for its persistence in gazelle populations. However, it is not known whether Mongolian gazelles can transmit FMDV or become persistent carriers. Further research on this topic to identify a carrier state is required. Furthermore, research on gazelle and livestock movements and distribution as well as the distribution of FMDV is also necessary.

Globally, workers in human, domestic animal, and wildlife health are starting to understand the importance of simultaneously considering all three traditionally separate fields when conducting comprehensive disease-management programs (Karesh and Cook, 2005). The FMDV–livestock–gazelle relationship discussed herein is a perfect example of the critical importance of understanding this interface. As elsewhere, FMDV leads to a massive disruption of the economy and movement of people and livestock in Mongolia during an outbreak, and gazelles may suffer direct and indirect impacts. Seminomadic pastoralists on the Eastern Steppes of Mongolia supplement their protein intake and reduce consumption of marketable livestock holdings by hunting gazelles. FMDV-related losses in livestock and gazelles consequently have a compound effect on rural economies. Conversely, appropriate and effective management actions, such as improving access to veterinary care for livestock on the Steppe and improving vaccination coverage, may lead to improved economics and livelihoods for one of the world's last pastoral cultures, as well as improve prospects for the conservation of the Mongolian gazelle.

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