Clinical presentation of experimental FMD virus SAT1 infection in goats

Introduction

Foot-and-mouth disease

- FMD affects cloven-hoofed livestock and wildlife
- Cattle, sheep, goats and pigs
- FMDV, genus *Aphthovirus*, family *Picornaviridae*
- FMDV serotypes: O, A, C, Asia-1, SAT1, SAT2 & SAT3
- The role of goats in FMD epidemiology is poorly understood
- FMDV serotypes SAT1, SAT2 & SAT3 are maintained by African buffalo (*Syncerus caffer*)
- FMD outbreaks of SAT1 & SAT2 are reported in livestock
Introduction

- Sheep and goats are not typically included in prophylactic FMD vaccination programmes

- Clinical signs of FMD in goats are considered to be mild but clinical descriptions have not been previously reported

- This presentation describes the clinical presentation of FMDV SAT1 infections in experimentally challenged indigenous South African goats
Materials and methods

- Goats seronegative for FMDV-specific antibodies

- Challenged with $10^{4.57} \text{TCID}_{50}$ FMDV SAT1 by intradermal lingual inoculation

- The challenge virus was a pool of goat adapted FMDV SAT1 SAR/10/10; SAR/21/10; SAR/8/10

- Isolated from cattle during an outbreak in 2010 within the FMD protection zone of South Africa

Challenged animals, n=5

In contact animals, n=2
Materials and methods

- Clotted blood for SPCE SP was collected at 0, 7 and 14 dpc
- Animals were observed daily for temperature and clinical scoring of FMD signs and lesions
- Nasal, oral and rectal swabs were collected at 0, 2, 4 and 6 dpc
- Probang specimens was collected from all animals at 6 dpc
- Whole blood was collected at 0, 2, 4 and 6 dpc
Materials and methods

FMD lesions were scored as follows:

- Fever (rectal temperatures $\geq 40^\circ C$) + 1
- Each secondary lesion away from the site of inoculation + 1 (secondary lesions on tongue, gum, lip, and each of four feet)
- Total clinical score was determined by simple addition
- Each goat could theoretically score a maximum of 8 points
Results

Rectal temperature -7 days pre challenge to 14 days post challenge of goats intra-dermolingually inoculated with $10^{4.57}$ TCID$_{50}$ FMDV SAT1 pool. Probang samples were collected at 6 dpc. Fever was defined as temp $\geq 40^\circ$C.
Results

Rectal temperature -7 days pre exposure and 0-14 days in contact for two unchallenged goats maintained with the challenged goats. Fever was defined as temperature $\geq 40^\circ C$. 
Results

Clinical lesion scores of five goats following intra-dermal lingual challenge with $10^{4.57}$ TCID$_{50}$ FMDV SAT1 pool and two unchallenged goats maintained in direct contact with experimentally infected goats.

<table>
<thead>
<tr>
<th>Group</th>
<th>Goat</th>
<th>0 dpc</th>
<th>1 dpc</th>
<th>2 dpc</th>
<th>3 dpc</th>
<th>4 dpc</th>
<th>5 dpc</th>
<th>6 dpc</th>
<th>7 dpc</th>
<th>8 dpc</th>
<th>9 dpc</th>
<th>10 dpc</th>
<th>11 dpc</th>
<th>12 dpc</th>
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<tbody>
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<td></td>
<td>L10</td>
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<td>1 [F]</td>
<td>1 [F]</td>
<td>1 [F]</td>
<td>1 [F]</td>
<td>0</td>
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<td></td>
<td>L17</td>
<td>0</td>
<td>1 [F]</td>
<td>1 [F]</td>
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<td>1 [F]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3 [F, LF, RF]</td>
<td>3 [F, LF, RF]</td>
<td>2 [LF, RF]</td>
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<tr>
<td></td>
<td>161</td>
<td>0</td>
<td>0</td>
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<td>0</td>
<td>1 [L]</td>
<td>2 [F, L]</td>
<td>1 [L]</td>
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</table>
Results

Solid phase competition ELISA (SPCE) percentage inhibition (PI) values for five goats experimentally infected with a pool of foot-and-mouth disease Southern African Territories 1 viruses and two in-contact exposed goats at the beginning and termination of the study.

<table>
<thead>
<tr>
<th>Group</th>
<th>Goat ID</th>
<th>Day of infection (d0)</th>
<th>Day of termination (d55)</th>
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<td></td>
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<td>PI</td>
<td>Interpretation</td>
</tr>
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<td>L7</td>
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<tr>
<td></td>
<td>L10</td>
<td>8</td>
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<tr>
<td></td>
<td>L17</td>
<td>16</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>L26</td>
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</tr>
<tr>
<td></td>
<td>166</td>
<td>-2</td>
<td>Negative</td>
</tr>
<tr>
<td>In-contact</td>
<td>L28</td>
<td>4</td>
<td>Negative</td>
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<tr>
<td></td>
<td>161</td>
<td>-1</td>
<td>Negative</td>
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</table>
Results

- All 5 inoculated goats developed elevated temperatures within 48 hours with a median fever duration of 5 days
- One goat had fever that lasted for 10 consecutive days
- Four goats had tongue lesions at the site of inoculation 72 h post challenge
- One goat developed a tongue lesion 2 days post challenge
- Presented with bilateral nasal discharges on 3 dpc and lasted for 3 days
- Two goat developed tongue lesion on day 2, nasal discharge on day 3 and foot lesion at 6 and 8 dpc respectively
- Two in-contact goats developed fever and secondary FMD lesions on the lips at 4 and 8 dpc respectively
FMD viral detection in clinical specimens as determined by RT-qPCR after challenge with FMDV SAT1 pool (in challenged goats) and unchallenged in-contact goats

<table>
<thead>
<tr>
<th>DPC</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td><strong>Group ID</strong></td>
<td><strong>Experimentally Infected</strong></td>
<td><strong>L7</strong></td>
<td><strong>L10</strong></td>
<td><strong>L17</strong></td>
<td><strong>L26</strong></td>
<td><strong>166</strong></td>
<td><strong>In-contacts</strong></td>
<td><strong>L28</strong></td>
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<tr>
<td><strong>ID</strong></td>
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<td>E⁺ O⁺</td>
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Discussion

- The clinical signs observed in this study were consistent with what has been reported for sheep
- The most prominent signs were fever, ulcerative oral and hoof lesions
- Possible upper respiratory tract involvement characterized by bilateral nasal discharge which has not been previously reported
- Two unchallenged goats maintained during the study only developed oral lip lesions following natural transmission via direct contact
- FMDV SAT1 infection causes mild clinical signs in indigenous South African goats after experimental challenge
- While inspecting goats for suspected FMD infections, attention should be focused on the oral mucosa of the lips and gums in addition to the tongue
Conclusions

- FMDV SAT1 caused mild clinical disease in South African indigenous goats characterized by fever, ulcerative oral and hoof lesions
- Experimentally challenged goats developed nasal discharges, which has not been previously reported
- There is a need to further investigate the role of goats in the epidemiology and transmission of FMD under field condition in southern Africa
Clinical presentation of FMD virus SAT1 infections in experimentally challenged indigenous South African goats


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ABSTRACT
Foot-and-mouth disease (FMD) is a transboundary animal disease that has a major impact on livestock production and international trade. The disease is caused by a group A, B, C or O virus of the genus Aphthovirus in the family Picornaviridae. The virus has a single stranded RNA that generally infects and replicates in epithelial cells of the mucous membranes of the oral cavity and respiratory tract of a variety of animals, including domesticated livestock and wildlife. The susceptibility of South African indigenous goats to FMDV Southern African Territories I (SAT1) was investigated after experimental challenge with a mixed SAT1 virus pool. In this study, we present the clinical manifestation of FMDV in five naive goats challenged via the intra-dermal route with 10^3 50% tissue culture infectious dose (TCID50) per goat containing equal proportions of SAT1/9/10, SAT1/7/11, and SAT1/21/10. The clinical responses of two vaccinated unchallenged goats maintained in-contact are also presented. Clinical scoring of FMDV infection and daily rectal temperatures were recorded and temperatures were compared to the normal range recorded for goats. All SAT1 infected goats developed fever of > 102°F on days 4 and 5 post-challenge with median fever duration of 8 days. The two unchallenged goats developed fever in 4 and 5 days post-contact with FMD lesions appearing at 4 and 8 days post-contact. Additional clinical signs observed included nasal discharge, desquamation of the lips and at the interdigital cleft lesions. The pooled FMDV SAT1 induced raised and solid clinical signs and nasal transudation in contact indigenious South African goats occurred.

1. Introduction
Foot-and-mouth disease (FMD) is caused by infection with FMD virus (FMDV), a small, positive-sense RNA virus in the genus Aphthovirus of the family Picornaviridae. There are 27 serotypes of FMDV with 7 main serogroups: A, O, C, Asia1 & Southern African Territories (SAT) 1, SAT2 & SAT3. The disease is characterized by fever, lameness and the appearance of vesicular and ulcerative oral and foot lesions (Arst et al., 2011; Horstgorn et al., 2018). Cattle, pigs, sheep and goats are epidemiologically important host species in many parts of the world with sheep having been involved in the spread of infection in numerous outbreaks (Anderson et al., 1976; Depland, 1992; Kryazhyk and Charbel, 1997; Samuel et al., 1999; Tsagris, 1999). Sheep and goats are important livestock species in many areas of the world, however, larger time gaps not typically included in prophylactic FMD vaccination programmes (Madimane et al., 2012, 2013; ESPER, 2018, 2019). The use of SAT1 in Africa, South Africa, and other parts of the SADC indicates that the clinical signs of SAT1 in goats are considered to be mild but clinical descriptions have not been previously reported. Antibodies against FMDV non-structural proteins suggestive of viral exposure in unvaccinated animals has been reported previously (Balinda et al., 2000; Bischof et al., 2016; Habiba et al., 2016; Naves et al., 2006; Lazarus et al., 2012). In the Southern African Development Community (SADC), the African buffalo (Syncerus caffer) is the wildlife reservoir host maintaining SAT1, SAT2 and SAT3 (Paton et al., 2018; Thomson et al., 2012; Thomson et al., 2019; Thomson et al., 2017). FMD outbreaks within the SADC have increased in frequency and in many situations, these outbreaks spread to more than one country. The 2015 event described by Usher et al. (2016) and Thomson and Thomson (2012). Traditional FMD control measures have become increasingly important with the new regulations of the SADC, which govern the importation of livestock and livestock products.

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