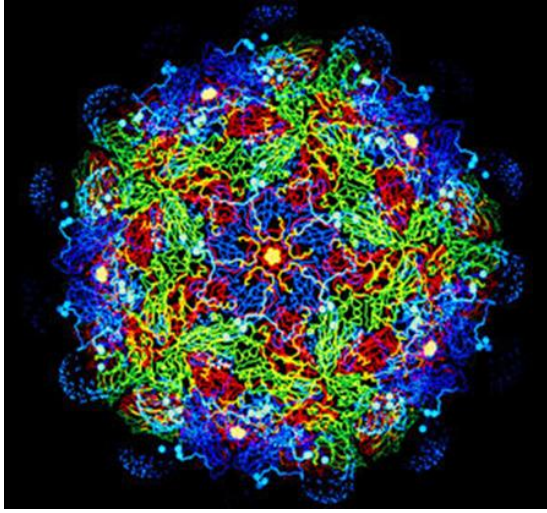
Clinical presentation of experimental FMD virus SAT1 infection in goats

David D. Lazarus, Paidamwoyo B. Mutowembwa, Mohamed M. Sirdar, Thapelo M. Rametse, Livio Heath, Pamela A. Opperman, Richard E. J. Burroughs, Geoffrey T. Fosgate

Introduction



Foot-and-mouth disease

- FMD affects cloven-hoofed livestock and wildlife
- Cattle, sheep, goats and pigs
- FMDV, genus *Aphthovirus*, family *Picornavirdae*
- 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

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Introduction

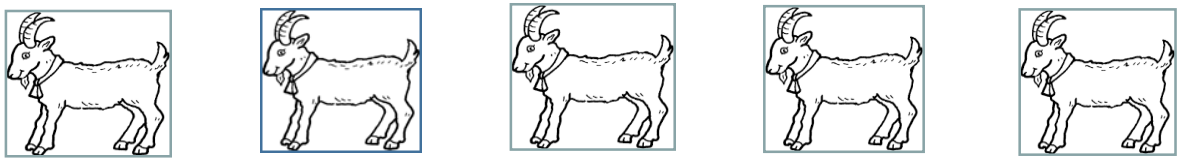
- Sheep and goats are not typically included in prophylactic FMD vaccination programmes

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

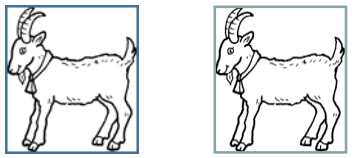
- This presentation describes the clinical presentation of FMDV SAT1 infections in experimentally challenged indigenous South African goats

Materials and methods

Challenged animals, n=5



In contact animals, n=2



- Goats seronegative for FMDV-specific antibodies
- Challenged with $10^{4.57}$ $TCID_{50}$ FMDV SAT1 by intradermolingual 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

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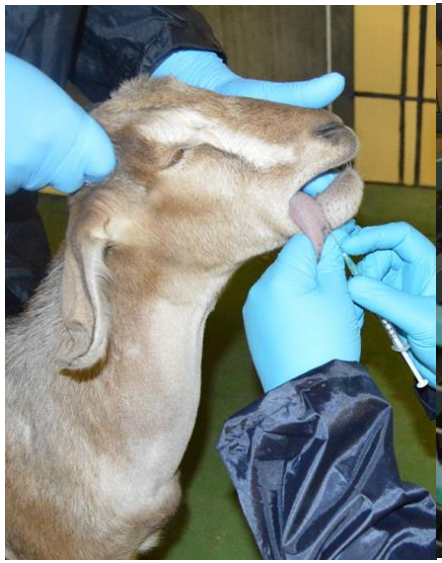
Materials and methods

- 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 for was collected at 0, 2, 4 and 6 dpc



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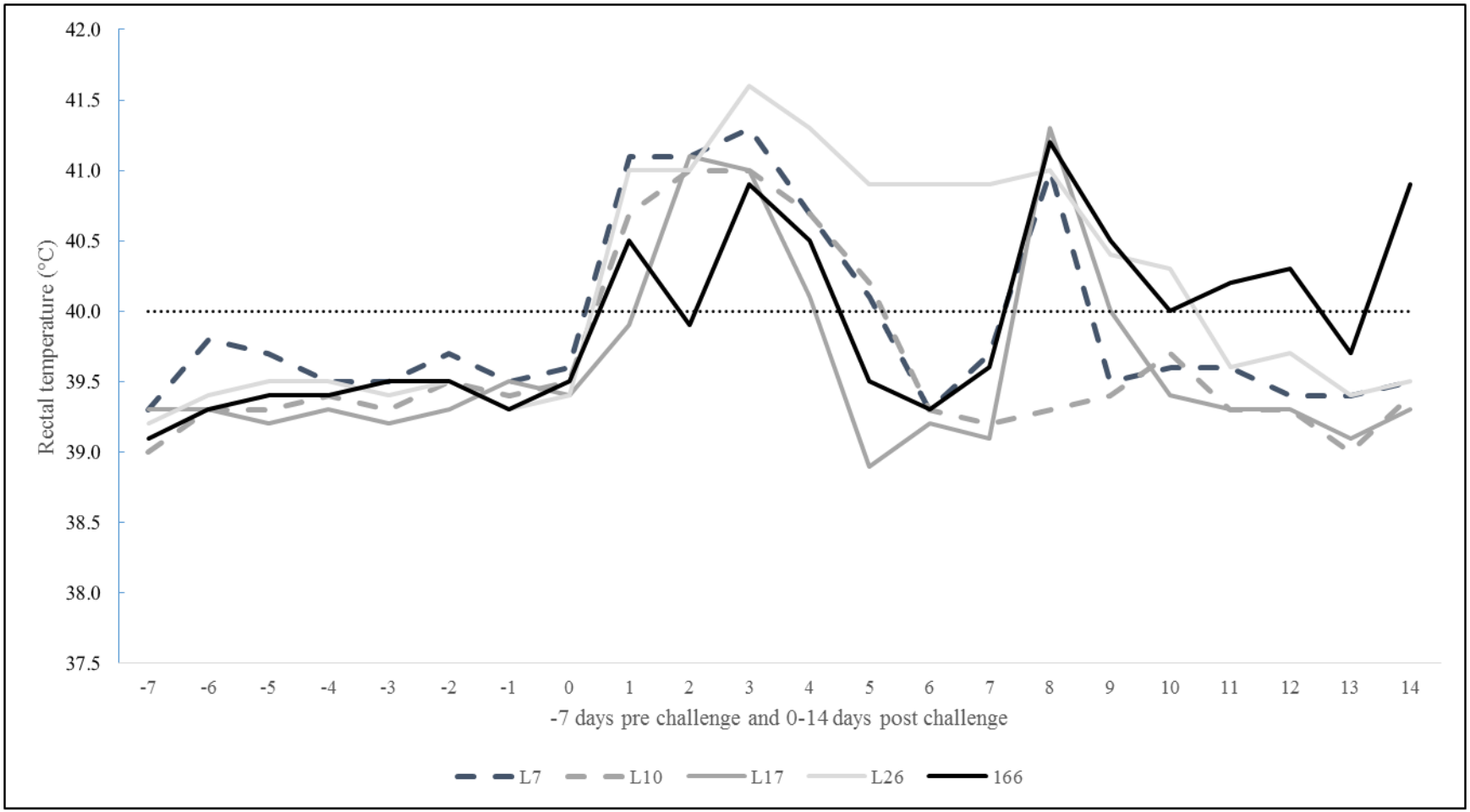
Materials and methods

FMD lesions were scored as follows:

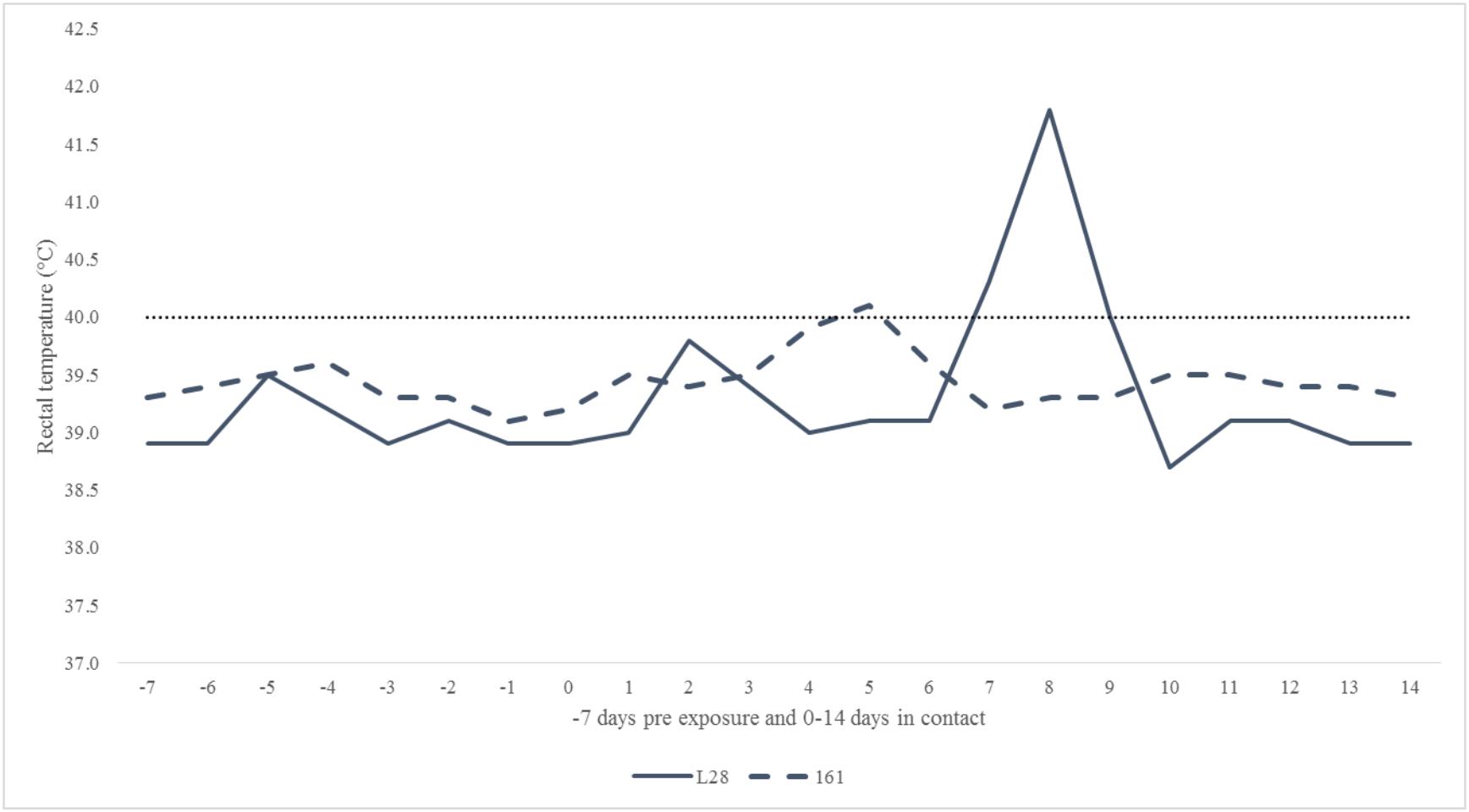
- Fever (rectal temperatures ≥40°C) + 1
- Each secondary lesion away from the site of inoculation + 1 (secondary lesions on tongue, gum, lip, and each of four feet)
- Total clinical score was determined by simple addition
- Each goat could theoretically score a maximum of 8 points

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 ≥***40***°C

Results

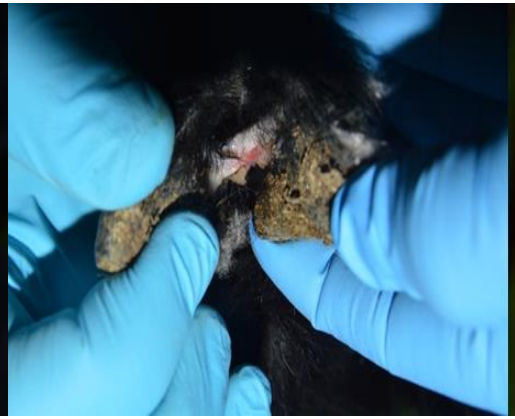


Rectal temperature -7 days pre exposure and 0-14 days in contact for two unchallenged goats maintained with the challenged goats. Fever was defined as temperature ≥*40*°C

Results

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

Group	Goat	0 dpc	1 dpc	2 dpc	3 dpc	4 dpc	5 dpc	6 dpc	7 dpc	8 dpc	9 dpc	10 dpc	11dpc	12 dpc
Experimentally infected	L7	0	1 [F]	1 [F]	1 [F]	1 [F]	1 [F]	1 [RH]	1 [RH]	2 [F, RH]	1 [RH]	1 [RH]	1 [RH]	0
	L10	0	1 [F]	1 [F]	1 [F]	1 [F]	1 [F]	0	0	0	0	0	0	0
	L17	0	0	1 [F]	1 [F]	1 [F]	0	0	0	1 [F]	1 [F]	0	0	0
	L26	0	1 [F]	1 [F]	1 [F]	1 [F]	1 [F]	1 [F]	1 [F]	3 [F, LF, RF]	3 [F, LF, RF]	3 [F, LF, RF]	2 [LF, RF]	0
	166	0	1 [F]	0	1 [F]	1 [F]	0	0	1 [L]	2 [F, L]	2 [F, L]	1 [F]	1 [F]	1 [F]
In-contacts	L28	0	0	0	0	0	0	0	1 [F]	2 [F, L]	2 [F, L]	1 [L]	0	0
	161	0	0	0	0	1 [L]	2 [F, L]	1 [L]	0	0	0	0	0	0

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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.

		Day of infection (d0)		Day of termination (d55)	
Group	Goat ID	PI	Interpretation	PI	Interpretation
Experimentally infected	L7	8	Negative	77	Positive
	L10	8	Negative	86	Positive
	L17	16	Negative	75	Positive
	L26	5	Negative	79	Positive
	166	−2	Negative	81	Positive
In-contact	L28	4	Negative	91	Positive
	161	−1	Negative	91	Positive

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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

DPC		1	2	3	4	5	6	7	8
Group	**ID**								
Experimentally Infected	L7	-	E^+ B^+	-	-	-	E^+ O^+	-	E^+
	L10	-	E^+ B^+	E^+	B^+	-	O^+	-	-
	L17	-	E^+	-	-	-	O^+	-	-
	L26	-	E^+ B^+	-	B^+	E^+	O^+	-	-
	166	-	-	-	E^+	-	O^+	-	-
In-contacts	161	-	-	-	E^+	-	O^+	-	-
	L28	-	-	-	-	-	O^+	-	E^-

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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

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ABSTRACT

Foot-and-mouth disease (FMD) is a transboundary animal disease that has a major impact on livestock production and trade. Foot-and-mouth disease virus (FMDV) is a single-stranded RNA virus that infects cloven-hoofed livestock and wildlife. The susceptibility of South African indigenous goats to FMDV Southern African Territories 1 (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-dermolingual route with $10^{4.57}$ 50% tissue culture infective dose ($TCID_{50}$) FMDV virus pool containing SAT1 SAR/8/10, SAR/10/10 and SAR/21/10. The clinical responses of two vaccinated unchallenged goats maintained as in-contacts are also presented. Clinical scoring of FMDV infection and daily rectal temperatures were recorded and temperatures ≥ 40 °C were defined as fever. All five challenged goats developed fever within 48 h post challenge with a median fever duration of 5 days. The two unchallenged goats developed fever at 5 and 9 days post-contact with FMD lesions appearing at 4 and 8 days post-contact. Additional clinical signs observed included nasal discharge, ulcerative oral mucosal lesions of the lip and ulcerative interdigital cleft lesions. The pooled FMDV SAT1 infection caused mild clinical signs and natural transmission to reduced-dose vaccinated in-contact indigenous 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*, family *Picornaviridae* (Han et al., 2018). FMDV infects cloven hoofed species and is classified into seven clinically indistinguishable serotypes (O, A, C, Asia-1 & 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 (Arzt et al., 2011; Horsington 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; Donaldson, 1999; Krystynak and Charlebois, 1987; Samuel et al., 1999; Tsaglias, 1995). Sheep and goats are important livestock species in many areas of the world but they are not typically included in prophylactic FMD vaccination programmes (Madhanmohan et al., 2012, 2011). Experimental studies in cattle, buffalo, sheep and pigs have contributed to our knowledge of the pathogenesis and transmission of FMDV (Alexandersen et al., 2003; Arzt et al., 2011; Kinsley et al., 2016; Paton et al., 2018; Stenfeldt et al., 2016).

The clinical signs of FMD 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., 2009; Bhebhe et al., 2016; Habiela et al., 2010; Hyera 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., 2003; Vosloo and Thomson, 2017). FMD outbreaks within the SADC have increased in frequency and in many situations, these outbreaks have persisted for a longer time (Jori et al., 2016; Penrith and Thomson, 2012). Traditional FMD control measures have become inadequate in some parts of the SADC during the last 10–15 years

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(Lazarus et al., 2018; Thomson et al., 2013; Vosloo and Thomson, 2017). Several countries in the SADC have reported outbreaks during the past decades, with South Africa officially reporting FMD outbreaks within the FMD free zone of the country in February 2011 and January 2019 (DAFF, 2019; OIE-WAHID, 2018, 2017; Vosloo and Thomson, 2017).

The official World Organisation for Animal Health (OIE) recogised FMD free zone status of South Africa has been temporarily suspended after detection of a FMDV serotype SAT2 outbreak in the free zone. As a follow up to the recent outbreak, our team identified seropositive sheep and goats within the outbreak area (unpublished data). The control of

facility, Onderstepoort Veterinary Research, Tra… Diseases, South Africa.

2.4. Clinical scoring

Goats were examined daily with their rectal … clinical signs recorded. Clinical signs of FMD were sco… viously described (Madhanmohan et al., 2011; Quan et al., 2004) with slight modifications: fever + 1; each secondary lesion away from the site of inoculation + 1. The total clinical score was determined by simple

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