



WRLFMD Quarterly Report

July-September 2012

Reference Laboratory Contract Report

10/25/2012
WRLFMD



This page deliberately blank



**OIE/FAO Reference Laboratory Contract Report^{1,2}
July-September 2012**

Foot-and-Mouth Disease

¹N.B. The content of this report is the property of WRLFMD®, The Pirbright Institute. For presentation, publication or any other public use, please contact Dr. Jef Hammond, The Pirbright Institute, jef.hammond@pirbright.ac.uk.

² Copies of all the individual reports cited herein can be obtained from Dr. Jef Hammond, The Pirbright Institute, jef.hammond@pirbright.ac.uk.

Summary

ASIA

Bhutan

Nine oesophageal-pharyngeal scrapings samples collected from cattle in Bhutan on 26/06/2012 were received on 28/08/2012. No FMD virus was detected in any of the samples.

PR China

On 06/09/2012, a single outbreak of **FMD type O** was reported in cattle and pigs in Muyu, Bomi, Tibet. No genotyping has been reported. This was the only report of a new FMD outbreak received by the OIE during the reporting period.

Iran

Eleven samples, collected from various locations during June and July 2012, were received. Two were **FMDV type O**, both belonging to the ME-SA toptype, PanAsia-2 lineage; however, one belonged to the FAR-09 sublineage and the other to the ANT-10 sublineage. Five samples typed as **FMDV A**, all of which belonged to the Iran-05 lineage; five belonged to the AFG-07 sublineage while one belonged to the SIS-10 sublineage. Three samples typed as **FMDV Asia 1** and belonged to the Sindh-08 lineage.

Saudi Arabia

Four samples collected in July 2012 from cattle in Durma near Riyadh were received. **FMDV type O** was isolated from all the samples and genotyping showed them to belong to the ME-SA toptype, PanAsia-2 lineages, ANT-10 sublineage.

AFRICA

Eritrea

Eighteen samples, collected from cattle and pigs during November and December 2011, were received. **FMDV type O** was identified in 15 samples, although only 14 of these were isolated in cell cultures. Genotyping showed that these 14 viruses belonged to the EA-3 toptype, but could be divided into three unnamed lineages. No virus was detected in three samples.

Ethiopia

Fifteen samples, collected from cattle and sheep between January and June 2012, were received. Seven samples were typed as **FMDV O**, but only six were isolated in cell cultures. These six isolates were identified as the EA-3 toptype. FMDV genome was detected in four samples. No virus was detected in four samples.

Sudan

Twenty-five samples, collected from cattle between December 2009 and November 2011 were received. Five were typed as **FMDV O** and belonged to the EA-3 toptype. Five were typed as **FMDV A** and all belonged to the AFRICA toptype, G-IV lineage. A single sample (from 2010) was identified as **FMDV SAT 2** and belonged to toptype VII, lineage Alx-12. This lineage was also identified in a single sample from Alexandria, Egypt in 2012. No virus was detected in 14 samples.

Tanzania

48 samples, collected from cattle during 2011 and 2012, were received from Tanzania. Typing results are pending and genotyping will be presented in the next quarterly report.

SOUTH AMERICA

No new outbreaks of FMD were reported in the region.

Uncharacterised FMD viruses

A number of outbreaks have occurred where samples have not been sent to the WRLFMD®. It is probable that the countries involved have performed their own genetic characterisation; however, through the OIE/FAO laboratory network we would also like to encourage the submission of samples (or complete VP1 sequences) to the WRLFMD.

An up-to-date list and reports of FMD viruses characterised by sequencing can be found at the following website: http://www.wrlfmd.org/fmd_genotyping/2012.htm.

Results from samples received at WRLFMD® (status of samples being tested) are shown in Table 1 and a complete list of clinical sample diagnostics made by the WRLFMD® between July and September 2012 is shown in Annex 1 Table A. A record of all samples received to The Pirbright Institute (July to September 2012) is shown in Annex 1 Table B.

Table 1: Status of sequencing of samples received by the WRLFMD® from July to September 2012.

Batch	Date Recd.	Country	Serotype	No. of samples	No. of sequences	Status
WRLFMD/2012/00025	12/07/2012	Saudi Arabia	O	4	4	Completed
WRLFMD/2012/00026	20/07/2012	Ethiopia	O	7	6	Completed*
WRLFMD/2012/00027	20/07/2012	Iran	O	2	2	Completed
			A	6	6	Completed
WRLFMD/2012/00028	20/07/2012	Sudan	O	5	5	Completed
			A	5	5	Completed
			SAT 2	1	1	Completed
WRLFMD/2012/00029	01/08/2012	Eritrea	O	15	14	Completed*
WRLFMD/2012/00031	08/08/2012	Tanzania	Pending			Pending
Total				45	43	

*, one sample was VP1 RT-PCR negative

Detailed Analysis:

ASIA

Iran

WRLFMD/2012/00027

Date received: 20/07/2012

No. of samples: 11

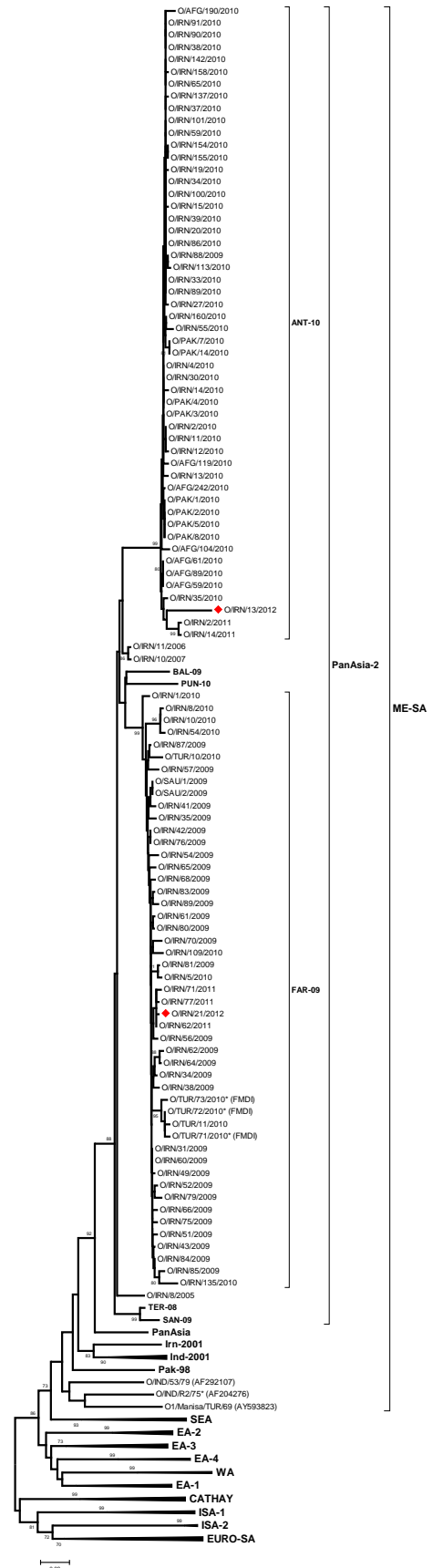
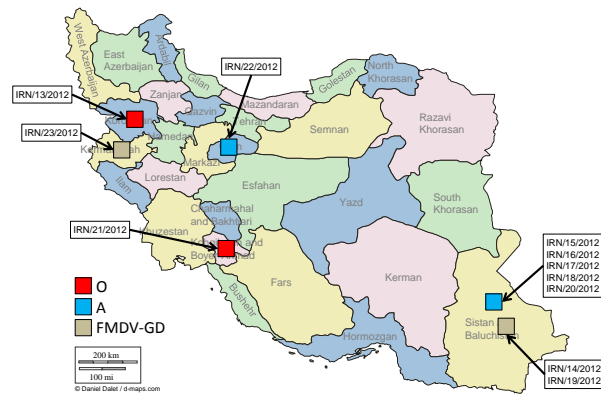
O/ME-SA/PanAsia-2^{FAR-09}: 1

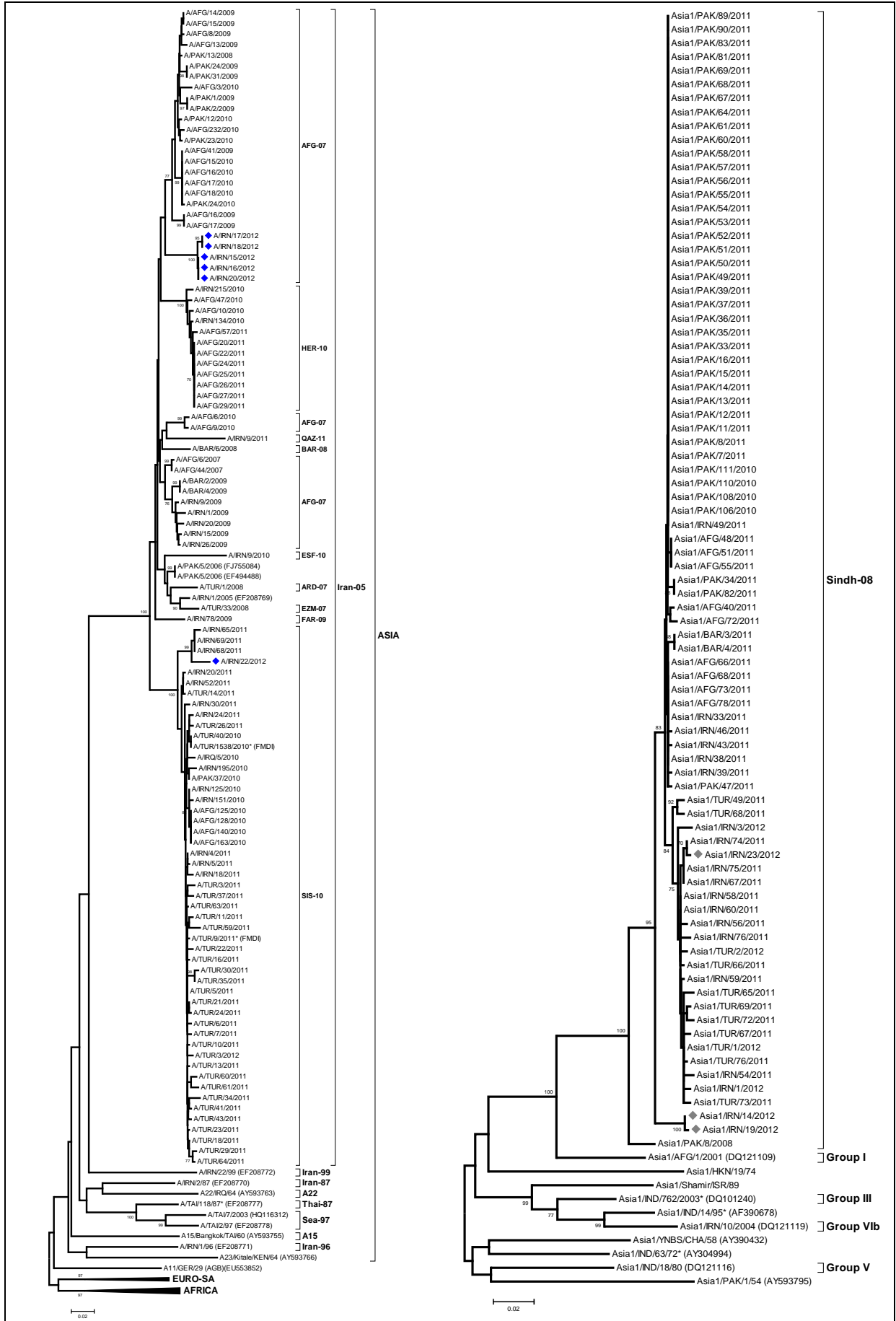
O/ME-SA/PanAsia-2^{ANT-10}: 1

A/ASIA/Iran-05^{AFG-07}: 5

A/ASIA/Iran-05^{SIS-10}: 1

Asia 1/ASIA/Sindh-08: 3





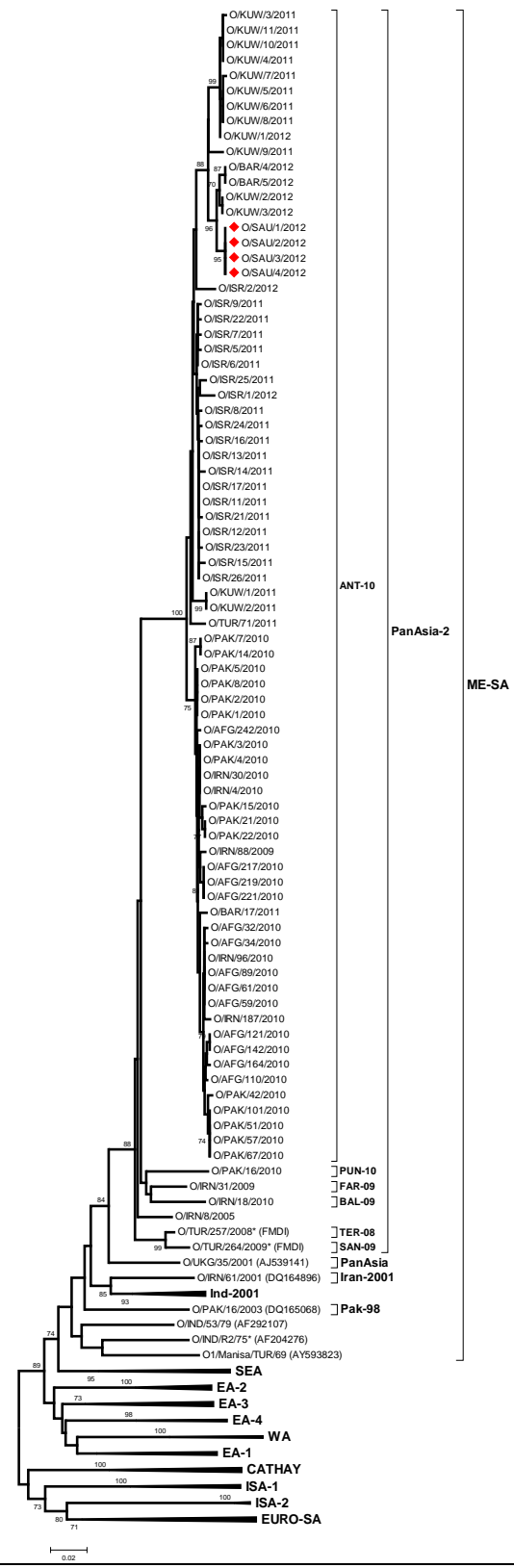
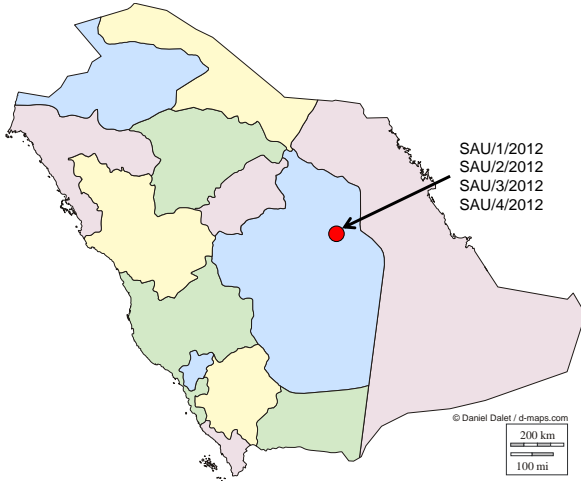
Saudi Arabia

WRLFMD/2012/00025

Date received: 12/07/2012

No. of samples: 4

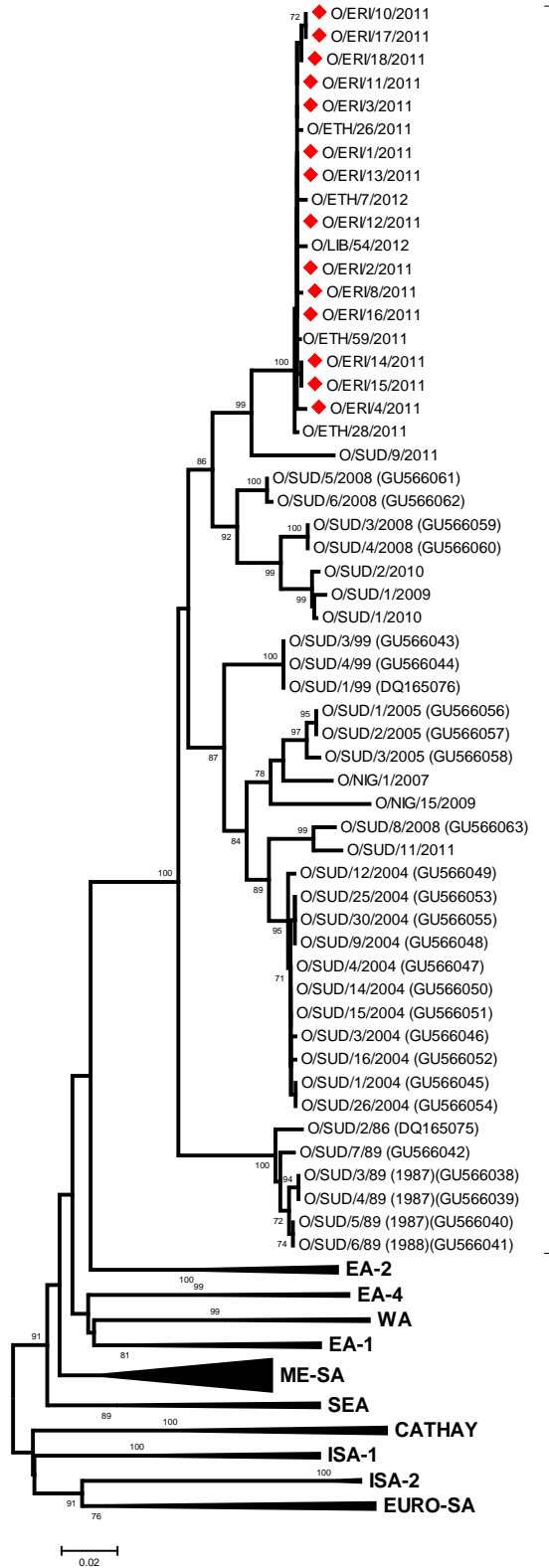
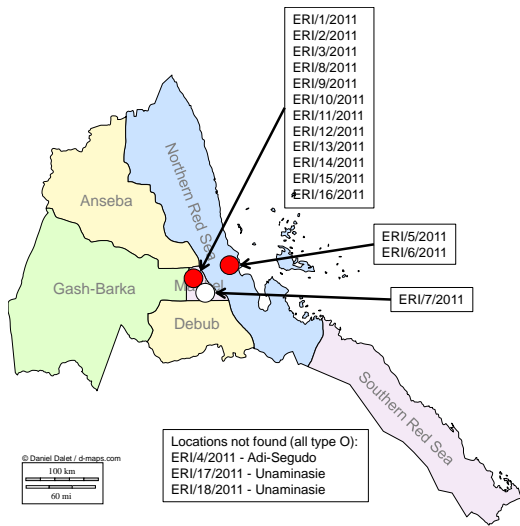
O/ME-SA/ PanAsia-2^{ANT-10}: 4



AFRICA

Eritrea

WRLFMD/2012/00029
 Date received: 01/08/2012
 No. of samples: 18
 O/EA-3: 14
 O (RT-PCR neg): 1
 NVD: 3



EA-3

Ethiopia

WRLFMD/2012/00026

Date received: 20/07/2012

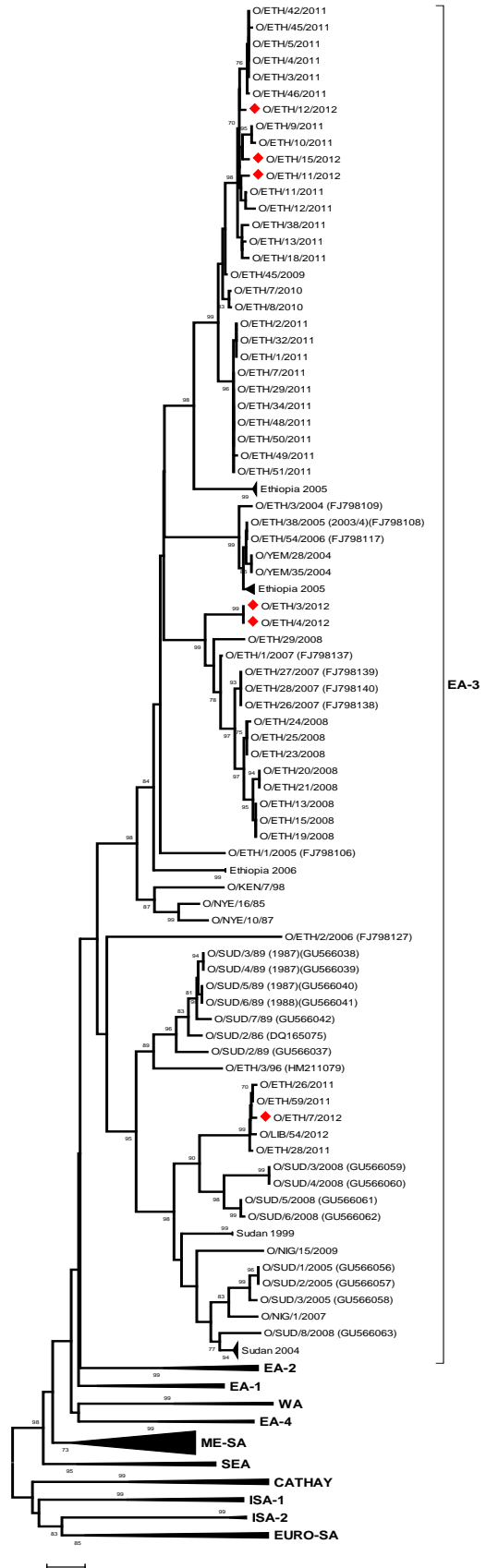
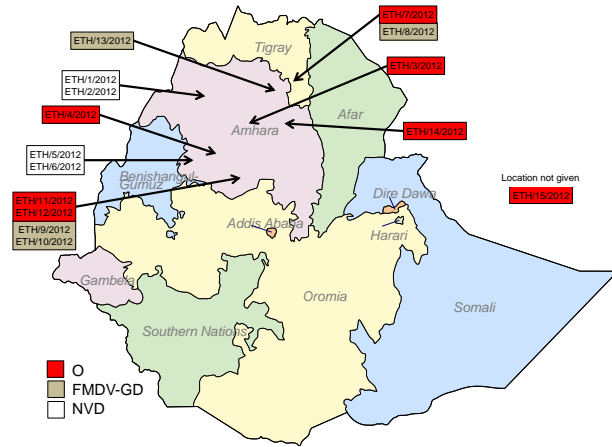
No. of samples: 15

O/EA-3: 6

O (RT-PCR neg): 1

FMDV-GD: 4

NVD: 4



Sudan

WRLFMD/2012/00028

Date received: 20/07/2012

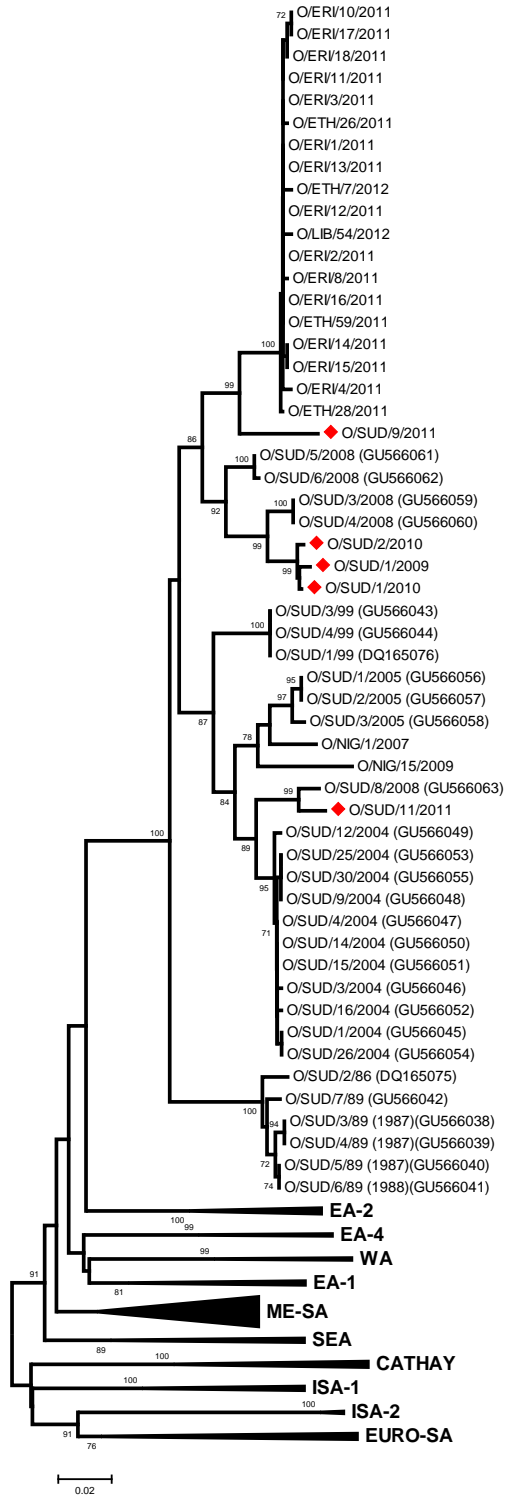
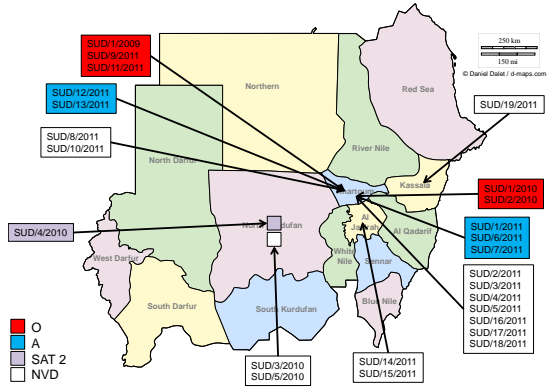
No. of samples: 25

O/EA-3: 5

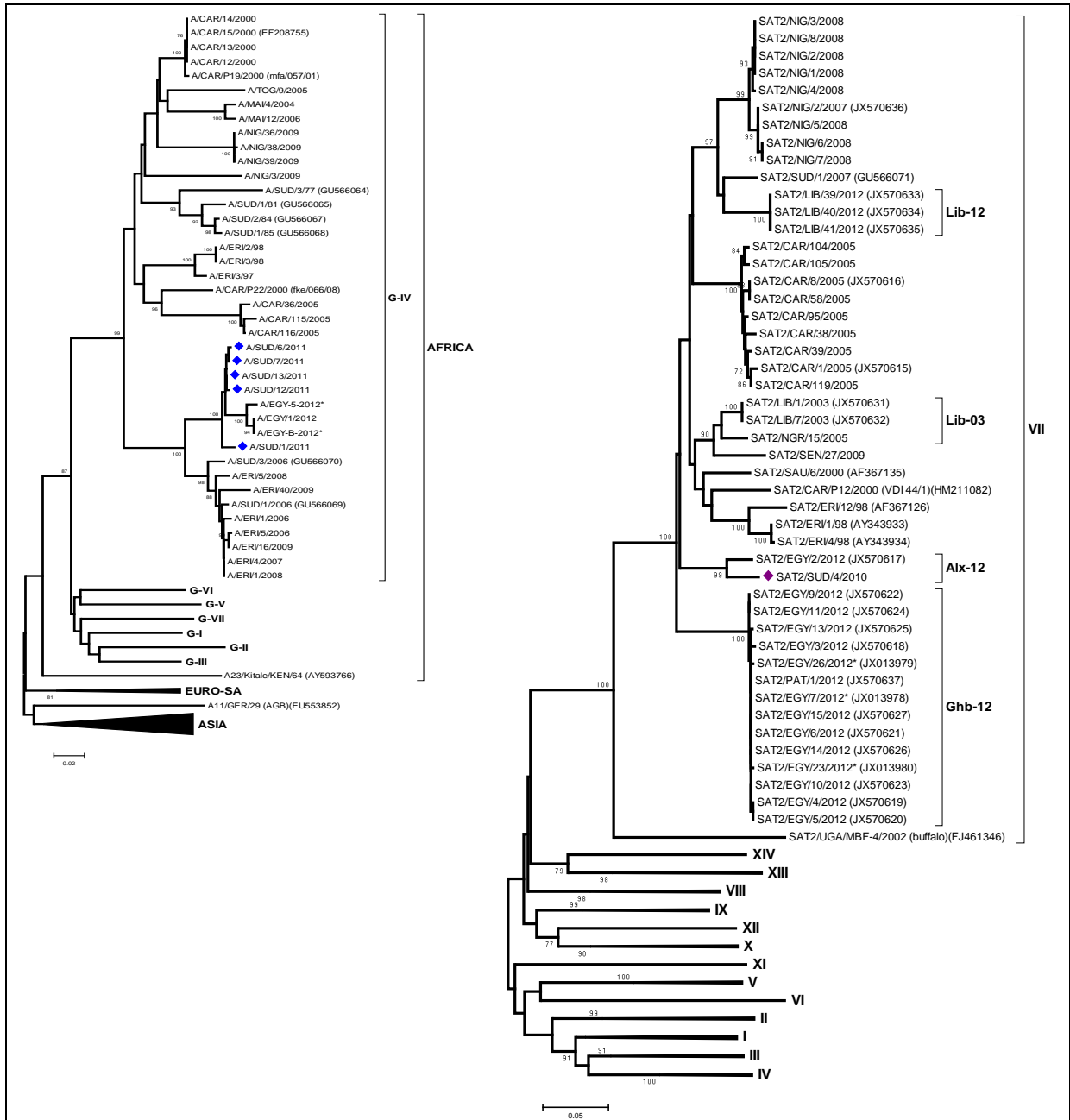
A/AFRICA/G-IV: 5

SAT2/VII/Alx-12: 1

NVD: 14



EA-3



Vaccine matching

Fourteen FMDV type O isolates (See Table C, Type O for details) from Japan, Iran, Turkey, Vietnam, Bahrain, Afghanistan, Malaysia and Sudan collected in 2011 and 2012 were analysed antigenically by the two dimensional virus neutralisation test (2dmVNT). All isolates were antigenically matched with O TUR 5/09 except the virus from Vietnam which showed matching with O TAW 98. Two viruses from Malaysia and one from Sudan showed close matching with O Manisa and O 4625 (Table C). Viruses from Japan, Malaysia and one virus from Vietnam also showed antigenic matches with the O 3039 vaccine.

Six FMDV type A viruses (See Table C, Type A for details) from Afghanistan and Iran collected during 2011 and 2012 showed antigenic matching with the A TUR 06 vaccine strain except two viruses from Iran by the two dimensional virus neutralisation test (2dmVNT) studies. One virus from Iran was antigenically matched with both A IRN 2005 and A Irq 24/64 (Table C).

Two FMDV type Asia 1 viruses (see table C, Type Asia 1 for details) from Iran collected in 2012 showed no antigenic match with ASIA 1 IND 8/79 and Asia 1 Shamir standard potency vaccine. However, when using antisera raised against high potency Asia 1 Shamir vaccine ($\geq 6PD_{50}$), both isolates showed matching (Table C).

One FMDV type SAT 1 virus (see table C, Type SAT 1 for details) from Kenya was analysed antigenically by the two dimensional virus neutralisation test (2dmVNT). There was no antigenic match between this virus and the SAT1 Rho vaccine (Table C).

Annex 1.

TABLE A: Clinical sample diagnostics made by the WRLFMD® between July-September 2012

Country	WRL for FMD Sample Identification	Animal	Date of Collection	Results		
				VI/ELISA	RT-PCR	Final report
BHUTAN	BHU 1/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
	BHU 2/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
	BHU 3/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
	BHU 4/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
	BHU 5/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
	BHU 6/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
	BHU 7/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
	BHU 8/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
	BHU 9/2012	CATTLE	26-Jun-12	NEG	NEG	NVD
ERITREA	ERI 1/2011	CATTLE	16-Nov-11	O	POS	O
	ERI 2/2011	CATTLE	17-Nov-11	O	POS	O
	ERI 3/2011	CATTLE	17-Nov-11	O	POS	O
	ERI 4/2011	CATTLE	17-Nov-11	O	POS	O
	ERI 5/2011	CATTLE	27-Nov-11	NEG	NEG	NVD
	ERI 6/2011	CATTLE	27-Nov-11	NEG	NEG	NVD
	ERI 7/2011	SWINE	05-Dec-11	NEG	POS	FMDV GD
	ERI 8/2011	SWINE	05-Dec-11	O	POS	O
	ERI 9/2011	SWINE	05-Dec-11	O	POS	O
	ERI 10/2011	SWINE	05-Dec-11	O	POS	O
	ERI 11/2011	SWINE	05-Dec-11	O	POS	O
	ERI 12/2011	SWINE	05-Dec-11	O	POS	O
	ERI 13/2011	SWINE	05-Dec-11	O	POS	O
	ERI 14/2011	SWINE	05-Dec-11	O	POS	O
	ERI 15/2011	SWINE	05-Dec-11	O	POS	O
	ERI 16/2011	SWINE	05-Dec-11	O	POS	O
	ERI 17/2011	CATTLE	05-Dec-11	O	POS	O
	ERI 18/2011	CATTLE	05-Dec-11	O	POS	O
ETHIOPIA	ETH 1/2012	CATTLE	14/01/2012	NOT TESTED	NEG	NVD
	ETH 2/2012	CATTLE	14/01/2012	NOT TESTED	NEG	NVD
	ETH 3/2012	CATTLE	03/02/2012	O	POS	O
	ETH 4/2012	CATTLE	09/02/2012	O	POS	O
	ETH 5/2012	CATTLE	09/02/2012	NOT TESTED	NT	NVD
	ETH 6/2012	CATTLE	09/02/2012	NEG	NEG	NVD
	ETH 7/2012	CATTLE	17/02/2012	O	POS	O
	ETH 8/2012	CATTLE	17/02/2012	NOT TESTED	POS	FMDV GD
	ETH 9/2012	CATTLE AND	20/03/2012	NOT TESTED	POS	FMDV GD

		SHEEP				
	ETH 10/2012	CATTLE AND SHEEP	20/03/2012	NOT TESTED	POS	FMDV GD
	ETH 11/2012	CATTLE AND SHEEP	20/05/2012	O	POS	O
	ETH 12/2012	CATTLE AND SHEEP	20/05/2012	O	POS	O
	ETH 13/2012	CATTLE	29/05/2012	NEG	POS	FMDV GD
	ETH 14/2012	CATTLE	20/06/2012	O	POS	O
	ETH 15/2012	NOT KNOWN	20/06/2012	O	POS	O
IRAN	IRN 13/2012	CATTLE	17/06/2012	O	POS	O
	IRN 14/2012	CATTLE	23/06/2012	ASIA-1	POS	ASIA-1
	IRN 15/2012	CATTLE	24/06/2012	A	POS	A
	IRN 16/2012	CATTLE	24/06/2012	A	POS	A
	IRN 17/2012	CATTLE	26/06/2012	A	POS	A
	IRN 18/2012	CATTLE	28/06/2012	A	POS	A
	IRN 19/2012	CATTLE	30/06/2012	ASIA-1	POS	ASIA-1
	IRN 20/2012	CATTLE	30/06/2012	A	POS	A
	IRN 21/2012	SHEEP	02/07/2012	O	POS	O
	IRN 22/2012	CATTLE	09/07/2012	A	POS	A
	IRN 23/2012	CATTLE	14/07/2012	ASIA-1	POS	ASIA-1
SAUDI ARABIA	SAU 1/2012	CATTLE	02/07/2012	O	POS	O
	SAU 2/2012	CATTLE	07/07/2012	O	POS	O
	SAU 3/2012	CATTLE	07/07/2012	O	POS	O
	SAU 4/2012	CATTLE	07/07/2012	O	POS	O
SUDAN	SUD 1/2009	CATTLE	13/12/2009	O	POS	O
	SUD 1/2010	CATTLE	11/01/2010	O	POS	O
	SUD 2/2010	CATTLE	12/01/2010	O	POS	O
	SUD 3/2010	CATTLE	09/02/2010	NEG	POS	FMDV GD
	SUD 4/2010	CATTLE	09/02/2010	SAT 2	POS	SAT 2
	SUD 5/2010	CATTLE	09/02/2010	NEG	POS	FMDV GD
	SUD 1/2011	CATTLE	28/02/2011	A	POS	A
	SUD 2/2011	CATTLE	28/02/2011	NEG	POS	FMDV GD
	SUD 3/2011	CATTLE	28/02/2011	NEG	POS	FMDV GD
	SUD 4/2011	CATTLE	01/03/2011	NEG	POS	FMDV GD
	SUD 5/2011	CATTLE	01/03/2011	NEG	POS	FMDV GD
	SUD 6/2011	CATTLE	01/03/2011	A	POS	A
	SUD 7/2011	CATTLE	01/03/2011	A	POS	A
	SUD 8/2011	CATTLE	03/03/2011	NEG	POS	FMDV GD
	SUD 9/2011	CATTLE	03/03/2011	O	POS	O
	SUD 10/2011	CATTLE	03/03/2011	NEG	POS	FMDV GD
	SUD 11/2011	CATTLE	03/03/2011	O	POS	O
	SUD 12/2011	CATTLE	03/03/2011	O	POS	O
	SUD 13/2011	CATTLE	03/03/2011	A	POS	A
	SUD 14/2011	CATTLE	14/03/2011	NEG	POS	FMDV GD
	SUD 15/2011	CATTLE	14/03/2011	NEG	POS	FMDV GD
	SUD 16/2011	CATTLE	02/05/2011	NEG	NEG	NVD
	SUD 17/2011	CATTLE	02/05/2011	NEG	NEG	NVD
	SUD 18/2011	CATTLE	02/05/2011	NEG	NEG	NVD
	SUD 19/2011	CATTLE	24/11/2011	NEG	POS	FMDV GD
TANZANIA	TAN 12/2011	CATTLE	08-Feb-11	NEG	NEG	NVD
	TAN 13/2011	CATTLE	08-Feb-11	NEG	POS	FMDV GD

TAN 1/2012	CATTLE	03-Feb-12	SAT 2	POS	SAT 2
TAN 2/2012	CATTLE	03-Feb-12	NEG	POS	FMDV GD
TAN 3/2012	CATTLE	04-Feb-12	SAT 2	POS	SAT 2
TAN 4/2012	CATTLE	04-Feb-12	NEG	POS	FMDV GD
TAN 5/2012	CATTLE	29-Feb-12	SAT 2	POS	SAT 2
TAN 6/2012	CATTLE	29-Feb-12	NEG	POS	FMDV GD
TAN 7/2012	CATTLE	01-Mar-12	SAT 2	POS	SAT 2
TAN 8/2013	CATTLE	01-Mar-12	NEG	POS	FMDV GD
TAN 9/2014	CATTLE	02-Mar-12	SAT 2	POS	SAT 2
TAN 10/2012	CATTLE	02-Mar-12	SAT 2	POS	SAT 2
TAN 11/2012	CATTLE	25-Mar-12	SAT 1	Pending	SAT 1
TAN 12/2012	CATTLE	25-Mar-12	SAT 1	Pending	SAT 1
TAN 13/2012	CATTLE	17-Apr-12	SAT 2	Pending	SAT 2
TAN 14/2012	CATTLE	17-Apr-12	SAT 2	Pending	SAT 2
TAN 15/2012	CATTLE	18-Apr-12	SAT 2	Pending	SAT 2
TAN 16/2012	CATTLE	18-Apr-12	SAT 2	Pending	SAT 2
TAN 17/2012	CATTLE	18-Apr-12	NEG	Pending	Pending
TAN 18/2013	CATTLE	28-Apr-12	SAT 2	Pending	SAT 2
TAN 19/2014	CATTLE	28-Apr-12	SAT 2	Pending	SAT 2
TAN 20/2012	CATTLE	29-Apr-12	NEG	Pending	Pending
TAN 21/2012	CATTLE	29-Apr-12	NEG	Pending	Pending
TAN 22/2012	CATTLE	30-Apr-12	SAT 1	Pending	SAT 1
TAN 23/2012	CATTLE	30-Apr-12	SAT 1	Pending	SAT 1
TAN 24/2012	CATTLE	01-May-12	NEG	Pending	Pending
TAN 25/2012	CATTLE	01-May-12	SAT 1	Pending	SAT 1
TAN 26/2012	CATTLE	02-May-12	NEG	Pending	Pending
TAN 27/2012	CATTLE	02-May-12	Pending	Pending	Pending
TAN 28/2013	CATTLE	03-May-12	NEG	Pending	Pending
TAN 29/2014	CATTLE	03-May-12	NEG	Pending	Pending
TAN 30/2012	CATTLE	04-May-12	NEG	Pending	Pending
TAN 31/2012	CATTLE	04-May-12	NEG	Pending	Pending
TAN 32/2012	CATTLE	05-May-12	SAT 2	Pending	SAT 2
TAN 33/2012	CATTLE	05-May-12	NEG	Pending	Pending
TAN 34/2012	CATTLE	25-May-12	SAT 2	Pending	SAT 2
TAN 35/2012	CATTLE	27-May-12	SAT 2	Pending	SAT 2
TAN 36/2012	CATTLE	27-May-12	SAT 2	Pending	SAT 2
TAN 37/2012	CATTLE	27-May-12	SAT 2	Pending	SAT 2
TAN 38/2013	CATTLE	31-May-12	O	Pending	O
TAN 39/2014	CATTLE	31-May-12	O	Pending	O
TAN 40/2012	CATTLE	01-Jun-12	A	Pending	A
TAN 41/2012	CATTLE	01-Jun-12	A	Pending	A
TAN 42/2012	CATTLE	02-Jun-12	Pending	Pending	Pending
TAN 43/2012	CATTLE	02-Jun-12	Pending	Pending	Pending
TAN 44/2012	CATTLE	12-Jul-12	Pending	Pending	Pending
TAN 45/2012	CATTLE	12-Jul-12	Pending	Pending	Pending
TAN 46/2012	CATTLE	12-Jul-12	Pending	Pending	Pending

BOTSWANA

30 samples received on 28/09/2012. Still awaiting sample details from sender.

TOTAL : 160

FMD(V) Foot-and-mouth disease (virus)
 GD Genome detected
 NGD No genome detected
 VI/ELISA FMDV serotype identified following virus isolation in cell culture and antigen ELISA

RT-PCR	Reverse transcription polymerase chain reaction on epithelial suspension for FMD (or SVD) viral genome
NVD	No foot-and-mouth disease, swine vesicular disease or vesicular stomatitis virus detected

TABLE B: Summary of samples collected and received to The Pirbright Institute (July-September 2012)

Country	No. of samples	Virus isolation in cell culture/ELISA							RT-PCR for FMD (or SVD) virus (where appropriate)		
		FMD virus serotypes							NVD	Positive	Negative
		O	A	C	SAT 1	SAT 2	SAT 3	Asia 1			
BHUTAN	9	-	-	-	-	-	-	-	9	-	9
BOTSWANA	30	-	-	-	-	-	-	-	-	-	-
ERITREA	18	-	-	-	-	-	-	-	3	16	2
ETHIOPIA	15	4	-	-	-	-	-	-	2	11	3
IRAN	11	2	6	-	-	-	-	3	-	11	-
SAUDI ARABIA	4	-	-	-	-	-	-	-	-	4	-
SUDAN	25	6	4	-	-	1	-	-	14	22	3
TANZANIA	48	2	2	-	5	17	-	-	16	11	1
TOTAL	130	14	12	0	5	18	0	3	44	75	18

FMD(V)	Foot-and-mouth disease (virus)
VI/ELISA	FMDV serotype identified following virus isolation in cell culture and antigen ELISA
RT-PCR	Reverse transcription polymerase chain reaction on epithelial suspension for FMD (or SVD) viral genome
NVD	No foot-and-mouth disease, swine vesicular disease or vesicular stomatitis virus detected

TABLE C: Antigenic characterisation of FMD field isolates by matching with vaccine strains by 2dmVNT from 1st July to 30th September 2012**Type O:**

Vaccine Matching studies for serotype O FMDV by VNT-WRL FMD					
WRL SAMPLE REF	O 3039	O 4625	O Manisa	O Taw98	O Tur 5/09(boost)
Jpn 01/2010	M	N	N	M	M
Irn 61/2011		M	N		M
Irn 78/2011		M	N		M
Tur 71/2011		M	N		M
Vit 1/2012	N	N	N	M	N
Vit 12/2012	M	N	N	M	N
Bar 4/2012		M	N		M
Bar 5/2012		M	N		M
Afg 67/2011		N	N		M
May 06/12	M	N	N	N	M
May 12/12	M	N	M	M	M
May 16/12	N	M	M	M	M
Sud 1/09		M	M		M
Sud 11/11		M	M		M

Type A:

Vaccine Matching studies for serotype A FMDV by VNT-WRL FMD					
WRL SAMPLE REF	A Iran 2005	A Irn 87	A Irn 96	A Irq 24/64	A Tur 06
Afg 69/2011	N			N	M
Afg 75/2011	N			N	M
Irn 55/2011	M			M	M
Irn 12/2012	N			N	M
Irn 15/2012	N	N	N	N	N
Irn 22/2012	N	N	N	N	N

Type Asia 1

Vaccine Matching studies for serotype Asia 1 FMDV by VNT-WRL FMD				
WRL SAMPLE REF	TYPE	Asia1 IND 8/79	Asia1 Shamir	Asia1 Shamir($\geq 6PD_{50}$)
IRN 14/2012	ASIA1	N	N	M
IRN 23/2012	ASIA1	N	N	M

Type SAT 2:

Vaccine Matching studies for serotype SAT 1 FMDV by VNT-WRL FMD		
WRL SAMPLE REF	TYPE	SAT1 Rho
Ken 02/11	SAT1	N

In the case of VNT:

M: $r_1 = \geq 0.3$. Suggests that there is a close relationship between field isolate and vaccine strain. A potent vaccine containing the vaccine strain is likely to confer protection.

N: $r_1 = < 0.3$. Suggests that the field isolate is so different from the vaccine strain that the vaccine is unlikely to protect

Annex 2. Recent FMD Publications cited by PubMed

- Seago J, Jackson T, Doel C, Fry E, Stuart D, Harmsen MM, Charleston B, Juleff, N. Characterization of epitope-tagged foot-and-mouth disease virus. J Gen Virol. 2012 Nov;93(Pt 11):2371-81. doi: 10.1099/vir.0.043521-0. Epub 2012 Jul 18. PubMed PMID: 22815275.
- Gladue DP, O'Donnell V, Baker-Branstetter R, Holinka LG, Pacheco JM, Fernandez-Sainz I, Lu Z, Brocchi E, Baxt B, Piccone ME, Rodriguez L, Borca MV. Foot-and-Mouth Disease Virus Nonstructural Protein 2C Interacts with Beclin1, Modulating Virus Replication. J Virol. 2012 Nov;86(22):12080-90. doi:10.1128/JVI.01610-12. Epub 2012 Aug 29. PubMed PMID: 22933281.
- Uddowla S, Hollister J, Pacheco JM, Rodriguez LL, Rieder E. A Safe Foot-and-Mouth Disease Vaccine Platform with Two Negative Markers for Differentiating Infected from Vaccinated Animals. J Virol. 2012 Nov;86(21):11675-85. doi: 10.1128/JVI.01254-12. Epub 2012 Aug 22. PubMed PMID:22915802.
- Anil KU, Sreenivasa BP, Mohapatra JK, Hosamani M, Kumar R, Venkataramanan R. Sequence analysis of capsid coding region of foot-and-mouth disease virus type A vaccine strain during serial passages in BHK-

- 21 adherent and suspension cells. *Biologicals*. 2012 Oct 16. pii: S1045-1056(12)00141-8. doi:10.1016/j.biologicals.2012.08.002. [Epub ahead of print] PubMed PMID: 23084588.
5. Mohana Subramanian B, Madhanmohan M, Sriraman R, Chandrasekhar Reddy RV, Yuvaraj S, Manikumar K, Rajalakshmi S, Nagendrakumar SB, Rana SK, Srinivasan VA. Development of foot-and-mouth disease virus (FMDV) serotype O virus-like-particles (VLPs) vaccine and evaluation of its potency. *Antiviral Res*. 2012 Oct 6. pii: S0166-3542(12)00226-4. doi: 10.1016/j.antiviral.2012.09.019.[Epub ahead of print] PubMed PMID: 23043941.
 6. Juleff N, Valdazo-González B, Wadsworth J, Wright CF, Charleston B, Paton DJ, King DP, Knowles NJ. Accumulation of Nucleotide Substitutions Occurring During Experimental Transmission of Foot-and-Mouth Disease Virus. *J Gen Virol*. 2012 Oct 3. [Epub ahead of print] PubMed PMID: 23034594.
 7. Carr BV, Lefevre EA, Windsor MA, Inghese C, Gubbins S, Prentice H, Juleff ND, Charleston B. CD4+ T-Cell Responses to Foot-and-Mouth Disease Virus in Vaccinated Cattle. *J Gen Virol*. 2012 Oct 3. [Epub ahead of print] PubMed PMID: 23034593.
 8. Dias CC, Moraes MP, Weiss M, Segundo FD, Perez-Martin E, Salazar AM, Santos Tde L, Grubman MJ. Novel Antiviral Therapeutics to Control Foot-and-Mouth Disease. *J Interferon Cytokine Res*. 2012 Oct;32(10):462-73. doi: 10.1089/jir.2012.0012. Epub 2012 Aug 27. PubMed PMID: 22924938.
 9. González-Magaldi M, Postigo R, de la Torre BG, Vieira YA, Rodríguez-Pulido M, López-Viñas E, Gómez-Puertas P, Andreu D, Kremer L, Rosas MF, Sobrino F. Mutations That Hamper Dimerization of Foot-and-Mouth Disease Virus 3A Protein Are Detrimental for Infectivity. *J Virol*. 2012 Oct;86(20):11013-23. Epub 2012 Jul 11. PubMed PMID: 22787230; PubMed Central PMCID: PMC3457133.
 10. Cao Y, Lu Z, Li P, Sun P, Fu Y, Bai X, Bao H, Chen Y, Li D, Liu Z. Improved neutralising antibody response against foot-and-mouth-disease virus in mice inoculated with a multi-epitope peptide vaccine using polyinosinic and poly-cytidylic acid as an adjuvant. *J Virol Methods*. 2012 Oct;185(1):124-8. Epub 2012 Jul 2. PubMed PMID: 22766183.
 11. Sun H, Lang Z, Zhu L, Huang D. Acquiring transgenic tobacco plants with insect resistance and glyphosate tolerance by fusion gene transformation. *Plant Cell Rep*. 2012 Oct;31(10):1877-87. Epub 2012 Jul 10. PubMed PMID: 22777591.
 12. Dar PA, Ganesh K, Nagarajan G, Sarika S, Reddy GR, Suryanarayana VV. Sindbis Virus Replicase-based DNA Vaccine Construct Encoding FMDV-specific Multivalent Epitope Gene: Studies on its Immune Responses in Guinea Pigs. *Scand J Immunol*. 2012 Oct;76(4):345-53. doi: 10.1111/j.1365-3083.2012.02733.x. PubMed PMID: 22702835.
 13. Ahmed HA, Salem SA, Habashi AR, Arafa AA, Aggour MG, Salem GH, Gaber AS, Selem O, Abdelkader SH, Knowles NJ, Madi M, Valdazo-González B, Wadsworth J, Hutchings GH, Mioulet V, Hammond JM, King DP. Emergence of Foot-and-Mouth Disease Virus SAT 2 in Egypt During 2012. *Transbound Emerg Dis*. 2012 Oct 1. doi: 10.1111/tbed.12015. [Epub ahead of print] PubMed PMID: 23025522.
 14. Jamal SM, Ferrari G, Hussain M, Nawroz AH, Aslami AA, Khan E, Murvatulloev S, Ahmed S, Belsham GJ. Detection and genetic characterization of foot-and-mouth disease viruses in samples from clinically healthy animals in endemic settings. *Transbound Emerg Dis*. 2012 Oct;59(5):429-40. doi: 10.1111/j.1865-1682.2011.01295.x. Epub 2011 Dec 28. PubMed PMID: 22212855.
 15. Abubakar M, Arshed MJ, Ali Q, Hussain M. Spatial trend of Foot and Mouth Disease virus (FMDV) serotypes in cattle and buffaloes, Pakistan. *Virol Sin*. 2012 Oct;27(5):320-3. doi: 10.1007/s12250-012-3271-8. Epub 2012 Oct 11. PubMed PMID: 23055008.
 16. Lin T, Shao J, Chang H, Gao S, Cong G, Du J. Generation of monoclonal antibodies against non-structural protein 3AB of foot-and-mouth disease virus. *Virol Sin*. 2012 Oct;27(5):316-9. doi: 10.1007/s12250-012-3261-x. Epub 2012 Oct 11. PubMed PMID: 23055007.
 17. Sedeh FM, Soleimanjahi H, Jalilian A, Mahravani H. Comparison of immune responses against FMD by a DNA vaccine encoding the FMDV/O/IRN/2007 VP1 gene and the conventional inactivated vaccine in an animal model. *Virol Sin*. 2012 Oct;27(5):286-91. doi: 10.1007/s12250-012-3258-5. Epub 2012 Sep 21. PubMed PMID: 23001482.

18. Kim SM, Park JH, Lee KN, Kim SK, Ko YJ, Lee HS, Cho IS. Enhanced inhibition of foot-and-mouth disease virus by combinations of porcine interferon- α and antiviral agents. *Antiviral Res.* 2012 Sep 21;96(2):213-220. doi:10.1016/j.antiviral.2012.09.009. [Epub ahead of print] PubMed PMID: 23000495.
19. Berryman S, Brooks E, Burman A, Hawes P, Roberts R, Netherton C, Monaghan P, Whelband M, Cottam E, Elazar Z, Jackson T, Wileman T. FMDV induces autophagosomes during cell entry via a class III PI3K-independent pathway. *J Virol.* 2012 Sep 19.[Epub ahead of print] PubMed PMID: 22993157.
20. Pedersen LE, Harndahl M, Nielsen M, Patch JR, Jungersen G, Buus S, Golde WT. Identification of peptides from foot-and-mouth disease virus structural proteins bound by class I swine leukocyte antigen (SLA) alleles, SLA-1*0401 and SLA-2*0401. *Anim Genet.* 2012 Sep 18. doi: 10.1111/j.1365-2052.2012.02400.x. [Epub ahead of print] PubMed PMID: 22984928.
21. Lavoria MA, Di-Giacomo S, Bucafusco D, Franco-Mahecha OL, Pérez-Filgueira DM, Capozzo AV. Avidity and subtyping of specific antibodies applied to the indirect assessment of heterologous protection against Foot-and-Mouth Disease Virus in cattle. *Vaccine.* 2012 Sep 18. pii: S0264-410X(12)01321-7. doi:10.1016/j.vaccine.2012.09.011. [Epub ahead of print] PubMed PMID: 23000129.
22. de Carvalho LM, Santos LB, Faria NR, de Castro Silveira W. Phylogeography of foot-and-mouth disease virus serotype O in Ecuador. *Infect Genet Evol.* 2012 Sep 15. pii: S1567-1348(12)00285-7. doi: 10.1016/j.meegid.2012.08.016. [Epub ahead of print] PubMed PMID: 22985683.
23. Breithaupt A, Depner K, Haas B, Alexandrov T, Polihronova L, Georgiev G, Meyer-Gerbaut H, Beer M. Experimental infection of wild boar and domestic pigs with a foot and mouth disease virus strain detected in the southeast of Bulgaria in December of 2010. *Vet Microbiol.* 2012 Sep 14;159(1-2):33-9. Epub 2012 Mar 16. PubMed PMID: 22503391.
24. Hui RK, Leung FC. Evolutionary trend of foot-and-mouth disease virus in Hong Kong. *Vet Microbiol.* 2012 Sep 14;159(1-2):221-9. Epub 2012 Mar 16. PubMed PMID:22472703.
25. Stenfeldt C, Lohse L, Belsham GJ. The comparative utility of oral swabs and probang samples for detection of foot-and-mouth disease virus infection in cattle and pigs. *Vet Microbiol.* 2012 Sep 12. pii: S0378-1135(12)00506-8. doi:10.1016/j.vetmic.2012.09.008. [Epub ahead of print] PubMed PMID: 23022683.
26. Zhang H, Li Y, Huang X, Zheng C. Global transcriptional analysis of model of persistent FMDV infection reveals critical role of host cells in persistence. *Vet Microbiol.* 2012 Sep 12. pii: S0378-1135(12)00505-6. doi:10.1016/j.vetmic.2012.09.007. [Epub ahead of print] PubMed PMID: 23022682.
27. Xue M, Wang H, Li W, Zhou G, Tu Y, Yu L. Effects of amino acid substitutions in the VP2 B-C loop on antigenicity and pathogenicity of serotype Asia1 foot-and-mouth disease virus. *Virol J.* 2012 Sep 10;9(1):191. [Epub ahead of print] PubMed PMID: 22963009.
28. Muleme M, Barigye R, Khaita ML, Berry E, Wamono AW, Ayebazibwe C. Effectiveness of vaccines and vaccination programs for the control of foot-and-mouth disease in Uganda, 2001-2010. *Trop Anim Health Prod.* 2012 Sep 7.[Epub ahead of print] PubMed PMID: 22956440.
29. Chai Z, Wang H, Zhou G, Yang D, Wang J, Yu L. Adenovirus-vectored type Asia1 foot-and-mouth disease virus (FMDV) capsid proteins as a vehicle to display a conserved, neutralising epitope of type O FMDV. *J Virol Methods.* 2012 Sep 4. pii:S0166-0934(12)00300-X. doi: 10.1016/j.jviromet. 2012.08.021. [Epub ahead of print] PubMed PMID: 22981982.
30. Wang J, Wang Y, Liu J, Ding L, Zhang Q, Li X, Cao H, Tang J, Zheng SJ. A critical role of N-myc and STAT interactor (Nmi) in foot-and-mouth disease virus (FMDV) 2C-induced apoptosis. *Virus Res.* 2012 Sep 2. pii: S0168-1702(12)00314-0. doi: 10.1016/j.virusres.2012.08.018. [Epub ahead of print] PubMed PMID: 22974759.
31. Guo H, Hao R, Qian H, Sun S, Sun D, Yin H, Liu Z, Liu X. Upconversion nanoparticles modified with aminosilanes as carriers of DNA vaccine for foot-and-mouth disease. *Appl Microbiol Biotechnol.* 2012 Sep;95(5):1253-63. Epub 2012 Apr 5. PubMed PMID: 22476264.

32. Liu K, Wang H, Long Y, Ye J, Yuan L. Coordinate lentiviral expression of Cre recombinase and RFP/EGFP mediated by FMDV 2A and analysis of Cre activity. *J Cell Biochem.* 2012 Sep;113(9):2909-19. doi: 10.1002/jcb.24168. PubMed PMID: 22532014.
33. Wang D, Fang L, Li K, Zhong H, Fan J, Ouyang C, Zhang H, Duan E, Luo R, Zhang Z, Liu X, Chen H, Xiao S. Foot-and-mouth disease virus 3C protease cleaves NEMO to impair innate immune signaling. *J Virol.* 2012 Sep;86(17):9311-22. Epub 2012 Jun 20. PubMed PMID: 22718831; PubMed Central PMCID: PMC3416110.
34. Lei W, Liang Q, Jing L, Wang C, Wu X, He H. BoLA-DRB3 gene polymorphism and FMD resistance or susceptibility in Wanbei cattle. *Mol Biol Rep.* 2012 Sep;39(9):9203-9. Epub 2012 Jun 29. PubMed PMID: 22744423; PubMed Central PMCID: PMC3404275.
35. Karapinar T, Eroksuz Y, Beytut E, Sozdutmaz I, Eroksuz H, Dabak M. Increased plasma cardiac troponin I concentration in lambs with myocarditis. *Vet Clin Pathol.* 2012 Sep;41(3):375-81. doi: 10.1111/j.1939-165X.2012.00448.x. Epub 2012 Jun 29. PubMed PMID: 22747688.
36. Madhanmohan M, Nagendrakumar SB, Manikumar K, Yuvaraj S, Parida S, Srinivasan VA. Development and evaluation of a real-time reverse transcription-loop-mediated isothermal amplification assay for rapid serotyping of foot-and-mouth disease virus. *J Virol Methods.* 2012 Aug 30. pii: S0166-0934(12)00294-7. doi:10.1016/j.jviromet.2012.08.015. [Epub ahead of print] PubMed PMID: 22960423.
37. Lannes N, Python S, Summerfield A. Interplay of foot-and-mouth disease virus, antibodies and plasmacytoid dendritic cells: virus opsonization under non-neutralizing conditions results in enhanced interferon-alpha responses. *Vet Res.* 2012 Aug 30;43(1):64. [Epub ahead of print] PubMed PMID: 22934974.
38. Rudreshappa AG, Sanyal A, Mohapatra JK, Subramaniam S, De A, Das B, Singanallur NB, Jangam AK, Muthukrishnan M, Villuppanoor SA, Pattnaik B. Emergence of antigenic variants with in serotype A foot and mouth disease virus in India and evaluation of a new vaccine candidate panel. *Vet Microbiol.* 2012 Aug 17;158(3-4):405-9. Epub 2012 Mar 2. PubMed PMID: 22445197.
39. Moniwa M, Embury-Hyatt C, Zhang Z, Hole K, Clavijo A, Copps J, Alexandersen S. Experimental foot-and-mouth disease virus infection in white tailed deer. *J Comp Pathol.* 2012 Aug-Oct;147(2-3):330-42. Epub 2012 Apr 18. PubMed PMID:22520809.
40. Lee DS, Lee KH, Jung S, Jo EJ, Han KH, Bae HJ. Synergistic effects of 2A-mediated polyproteins on the production of lignocellulose degradation enzymes in tobacco plants. *J Exp Bot.* 2012 Aug;63(13):4797-810. doi: 10.1093/jxb/ers159. Epub 2012 Jul 12. PubMed PMID: 22798663; PubMed Central PMCID: PMC3427999.
41. Valdazo-González B, Knowles NJ, Hammond J, King DP. Genome sequences of SAT 2 foot-and-mouth disease viruses from Egypt and Palestinian Autonomous Territories (Gaza Strip). *J Virol.* 2012 Aug;86(16):8901-2. PubMed PMID: 22843860; PubMed Central PMCID: PMC3421706.
42. Li Y, Swabey KG, Gibson D, Keel PJ, Hamblin P, Wilsden G, Corteyn M, Ferris NP. Evaluation of the solid phase competition ELISA for detecting antibodies against the six foot-and-mouth disease virus non-O serotypes. *J Virol Methods.* 2012 Aug;183(2):125-31. Epub 2012 Apr 25. PubMed PMID: 22561986.
43. Kasambula L, Belsham GJ, Siegismund HR, Muwanika VB, Ademun-Okurut AR, Masembe C. Serotype identification and VP1 coding sequence analysis of foot-and-mouth disease viruses from outbreaks in eastern and northern Uganda in 2008/9. *Transbound Emerg Dis.* 2012 Aug;59(4):323-30. doi:10.1111/j.1865-1682.2011.01276.x. Epub 2011 Nov 28. PubMed PMID: 22117844.
44. Pacheco JM, Tucker M, Hartwig E, Bishop E, Arzt J, Rodriguez LL. Direct contact transmission of three different foot-and-mouth disease virus strains in swine demonstrates important strain-specific differences. *Vet J.* 2012 Aug;193(2):456-63. Epub 2012 Feb 17. PubMed PMID: 22342891.
45. Opperman PA, Maree FF, Van Wyngaardt W, Vosloo W, Theron J. Mapping of antigenic determinants on a SAT2 foot-and-mouth disease virus using chicken single-chain antibody fragments. *Virus Res.* 2012 Aug;167(2):370-9. Epub 2012 Jun 12. PubMed PMID: 22698877.

46. Brito BP, Perez AM, Jamal SM, Belsham GJ, Pauszek SJ, Ahmed Z, Rodriguez LL. Foot-and-Mouth Disease Virus Serotype O Phylodynamics: Genetic Variability Associated with Epidemiological Factors in Pakistan. *Transbound Emerg Dis*. 2012 Jul 29. doi: 10.1111/j.1865-1682.2012.01366.x. [Epub ahead of print] PubMed PMID: 22846206.
47. Juleff ND, Maree FF, Waters R, Bengis RG, Charleston B. The importance of FMDV localisation in lymphoid tissue. *Vet Immunol Immunopathol*. 2012 Jul 15;148(1-2):145-8. Epub 2011 May 7. PubMed PMID: 21616546.
48. Malirat V, Bergmann IE, de Mendonça Campos R, Conde F, Quiroga JL, Villamil M, Salgado G, Ortiz S. Molecular epidemiology of foot-and-mouth disease virus type A in South America. *Vet Microbiol*. 2012 Jul 6;158(1-2):82-94. Epub 2012 Feb 17. PubMed PMID: 22397938.
49. Wang H, Xue M, Yang D, Zhou G, Wu D, Yu L. Insertion of type O-conserved neutralizing epitope into the foot-and-mouth disease virus type Asia1 VP1 G-H loop: effect on viral replication and neutralization phenotype. *J Gen Virol*. 2012 Jul;93(Pt 7):1442-8. Epub 2012 Apr 18. PubMed PMID: 22513388.
50. Madi M, Hamilton A, Squirrell D, Mioulet V, Evans P, Lee M, King DP. Rapid detection of foot-and-mouth disease virus using a field-portable nucleic acid extraction and real-time PCR amplification platform. *Vet J*. 2012 Jul;193(1):67-72. Epub 2011 Nov 23. PubMed PMID: 22115952.

Annex 3. RECOMMENDATIONS FROM WRLFMD® ON FMD VIRUS STRAINS TO BE INCLUDED IN FMDV ANTIGEN BANKS – September 2012

High Priority

O Manisa
 O PanAsia-2
 O BFS or Campos
 A24 Cruzeiro
 Asia 1 Shamir
 A Iran-05
 A22 Iraq
 SAT 2 Saudi Arabia (*or equivalent i.e. SAT 2 Eritrea*)

(not in order of importance)

Medium Priority

A Eritrea
 A Iran '96
 SAT 2 Zimbabwe
 A Iran 87 or A Saudi Arabia 23/86 (*or equivalent*)
 SAT 1 South Africa
 A Malaysia 97 (*or Thai equivalent such as A/NPT/TAI/86*)
 A Argentina 2001
 O Taiwan 97 (*pig-adapted strain or Philippine equivalent*)
 A Iran '99

(not in order of importance)

Low Priority

A15 Bangkok related strain
 A87 Argentina related strain
 C Noville
 SAT 2 Kenya
 SAT 1 Kenya
 SAT 3 Zimbabwe
 A Kenya

(not in order of importance)

