



# WRLFMD Quarterly Report October-December 2012

Reference Laboratory Contract Report

1/31/2013  
WRLFMD



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**OIE/FAO Reference Laboratory Contract Report<sup>1,2</sup>  
October-December 2012**

**Foot-and-Mouth Disease**

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<sup>2</sup> Copies of all the individual reports cited herein can be obtained from Dr. Jef Hammond, The Pirbright Institute, [jef.hammond@pirbright.ac.uk](mailto:jef.hammond@pirbright.ac.uk).

## Summary

### ASIA

#### *PR China*

On the 19/11/2012 an outbreak of **FMD type O** was reported in pigs in Puwan New District, Dalian, Liaoning province (adjacent to the Democratic People's Republic of Korea). On 12/12/2012 another outbreak due to FMD type O was reported in pigs in Xinbei, Changzhou, Jiangsu province which lies on the east coast of China. No genotyping has been reported.

#### *Pakistan*

Thirty-three samples were received in December 2012 and the results of typing and genotyping are pending and will be reported in the first quarter of 2013.

#### *Sri Lanka*

Five **FMD type O** viruses collected from three Sri Lankan provinces between 2009 and 2012 were closely related to each other and to other Sri Lankan viruses previously submitted. The phylogenetic tree suggests that this unnamed lineage has been in circulation in Sri Lanka since at least the late 1990's.

#### *Taiwan Province of China*

On the 24/09/2012 and 03/10/2012 two outbreaks of **FMD type O** were reported in pigs in Yuanshan Township (Outbreak 2), I-Lan County. Subsequently, on 23/11/2012 a third outbreak was reported in pigs in Dongshih Township, Yun-Lin County. The later outbreak was confirmed as **FMD type O** only by serology. No genotyping has been reported on the first two outbreaks.

#### *Vietnam*

Three **FMD type O** viruses from the south of Vietnam (collected in April and November 2012) belonged to the ME-SA toposotype, PanAsia lineage. They were closely related to each other and to other viruses circulating in Southeast Asia. Six **FMD type A** viruses (collected in October 2012 in Ho Chi Minh City) belonged to the ASIA toposotype, Sea-97 lineage and were closely related to each other and to viruses from Thailand and Malaysia from 2011-2012.

### AFRICA

#### *Botswana*

Twenty-one **FMDV SAT 2** viruses (received from the BVI) from outbreaks in the Maun Veterinary District (Matsebe Crush, Spanplek Crush and Nokaneng) all belonged to toposotype III, but those from Matsebe Crush and Nokaneng could be distinguished from those from Spanplek Crush suggesting the presence of two distinct evolutionary lineages in the district.

#### *Egypt*

Four **FMD type O** viruses from samples collected throughout Egypt belonged to toposotype EA-3 and were very closely related to viruses from Eritrea and Ethiopia, suggesting a recent introduction and widespread occurrence in Egypt. A similar virus has also been detected in Libya, close to the Egyptian border. Three **FMD type A** viruses belonged to the AFRICA toposotype, G-IV lineage and were closely related to viruses from Sudan in 2011, again suggesting a recent introduction of this lineage into Egypt. The samples came from Luxor and Giza, widely separated areas. Seven **FMD type SAT 2** viruses (all from the north-east Delta area) belonged to toposotype VII, Ghb-12 lineage and were closely related to each other and to SAT 2's previously found to be widely distributed in Egypt.

*Tanzania*

Two **FMD type O** viruses (from Arusha) belonged to the EA-2 toptype and were closely related to each other and next most closely related to viruses from Kenya in 2010-2011. Two **FMD type A** viruses (also from Arusha) belonging to the AFRICA toptype, G-I lineage, were identical to each other and related to viruses from Kenya and Tanzania in 2008-2009 and viruses from the DR Congo in 2011. Eight **FMD SAT 1** viruses from Manyara belonged to toptype I (NWZ) and were related to older viruses from Tanzania and Kenya (1999-2011). Seventeen **FMD type SAT 2** viruses (14 from Mara and three from Manyara) belonged to toptype IV and were closely related to viruses from Tanzania and Kenya in 2011.

*Zambia*

Two **FMDV SAT 2** samples (received from the BVI) from an outbreak in Mbala, Northern Zambia in February 2012 belonged to toptype IV and were closely related to viruses from Tanzania (2011-2012). Four **FMDV SAT 1** viruses from outbreaks in the Kazangula area in June 2012 belonged to toptype III (WZ) but were not closely related to other SAT 1 viruses.

**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](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 October and December 2012 is shown in Annex 1 Table A. A record of all samples received to the Pirbright Institute (October to December 2012) is shown in Annex 1 Table B.

**Table 1:** Status of sequencing of samples received by the WRLFMD® from October to December 2012.

Batch	Date Recd.	Country	Serotype	No. of samples	No. of sequences	Status
WRLFMD/2012/00031	08/08/2012	Tanzania	O	2	2	Completed
			A	2	2	Completed
			SAT 1	9	9	Completed
			SAT 2	17	16	Completed*
WRLFMD/2012/00032	02/10/2012	Egypt	O	4	4	Completed
			A	3	3	Completed
			SAT 2	7	7	Completed
WRLFMD/2012/00033	25/10/2012	Sri Lanka	O	6	5	Completed*
WRLFMD/2012/00034	16/11/2012	Vietnam	O	3	3	Completed
			A	6	6	Completed
WRLFMD/2012/00035	28/09/2012	Botswana	SAT 2	23	23	Completed
WRLFMD/2012/00036	28/09/2012	Zambia	SAT 1	4	4	Completed
			SAT 2	2	2	Completed
WRLFMD/2012/00037	13/12/2012	Pakistan		33		Typing pending
Total				121	86	

\*, one sample was VP1 RT-PCR negative

**Detailed Analysis:**

**ASIA**

**Sri Lanka**

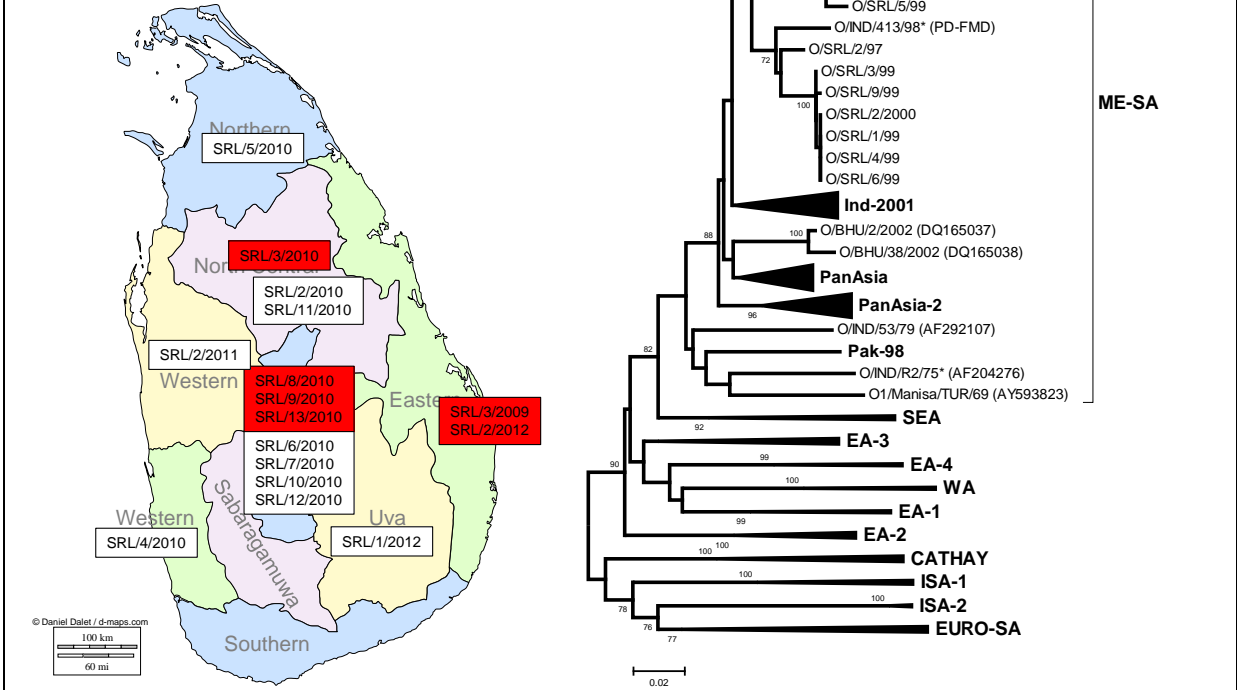
WRLFMD/2012/00033

Date received: 25/10/2012

No. of samples: 16

O/ME-SA/unnamed lineage: 6

NVD: 10



**Vietnam**

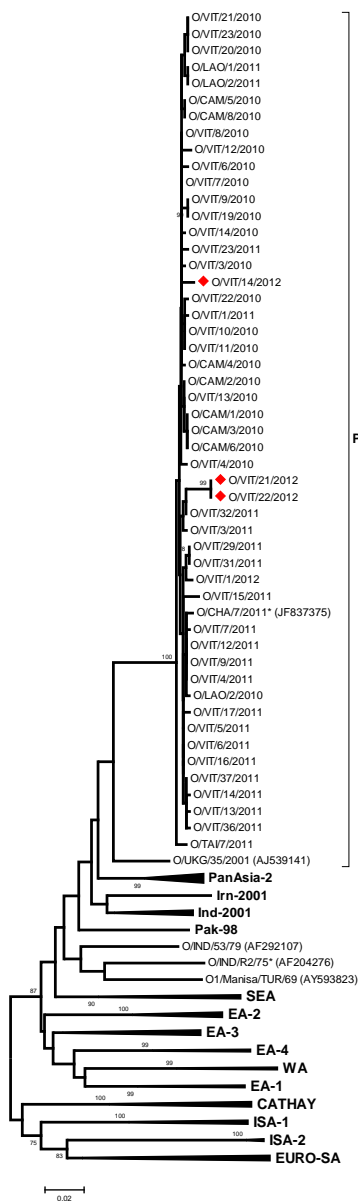
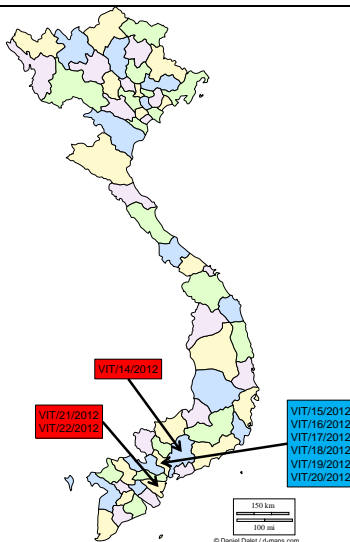
WRLFMD/2012/00034

Date received: 16/11/2012

No. of samples: 9

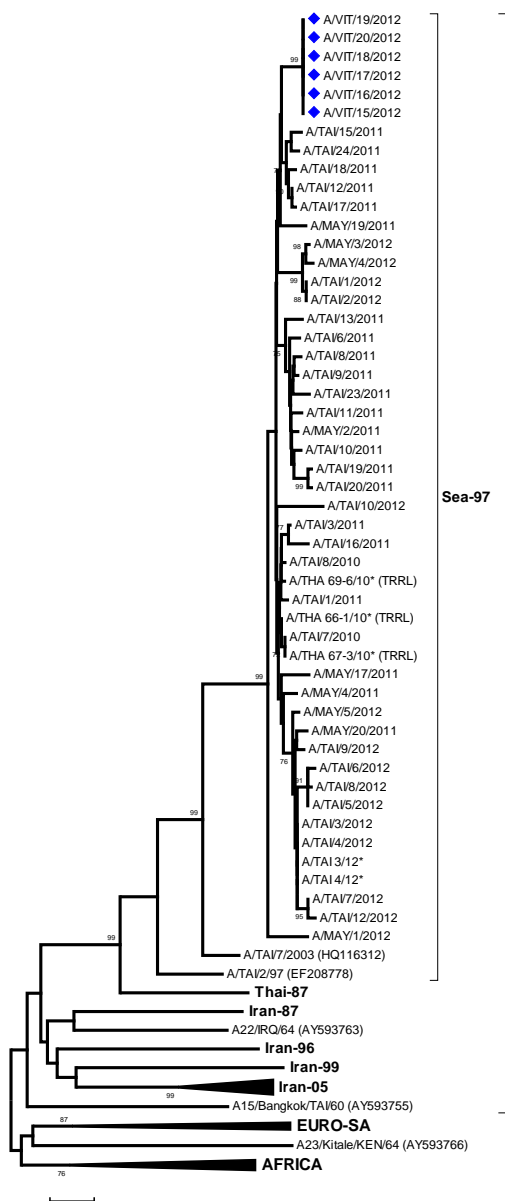
O/ME-SA/PanAsia: 3

A/ASIA/Sea-97: 6



PanAsia

ME-SA



Sea-97

ASIA



**AFRICA**

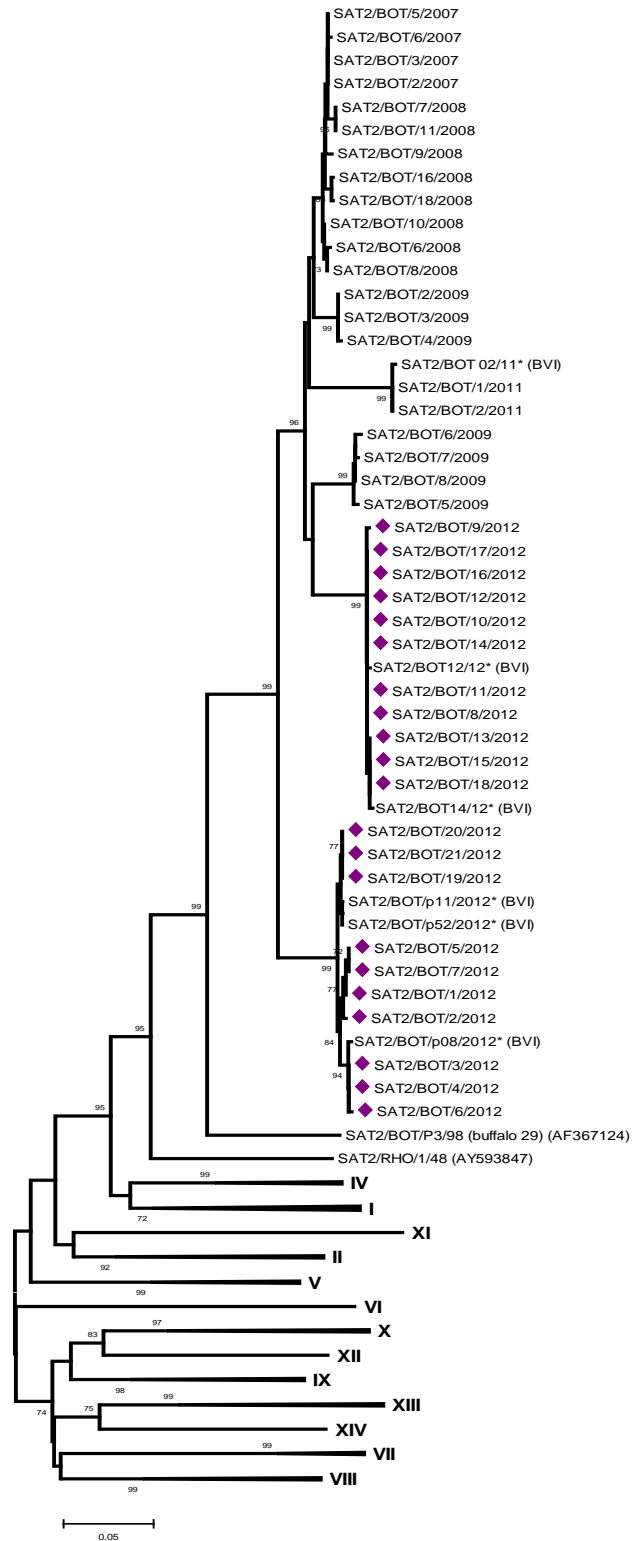
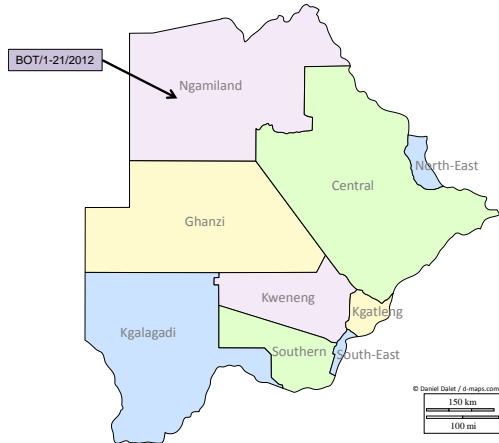
**Botswana**

WRLFMD/2012/00035

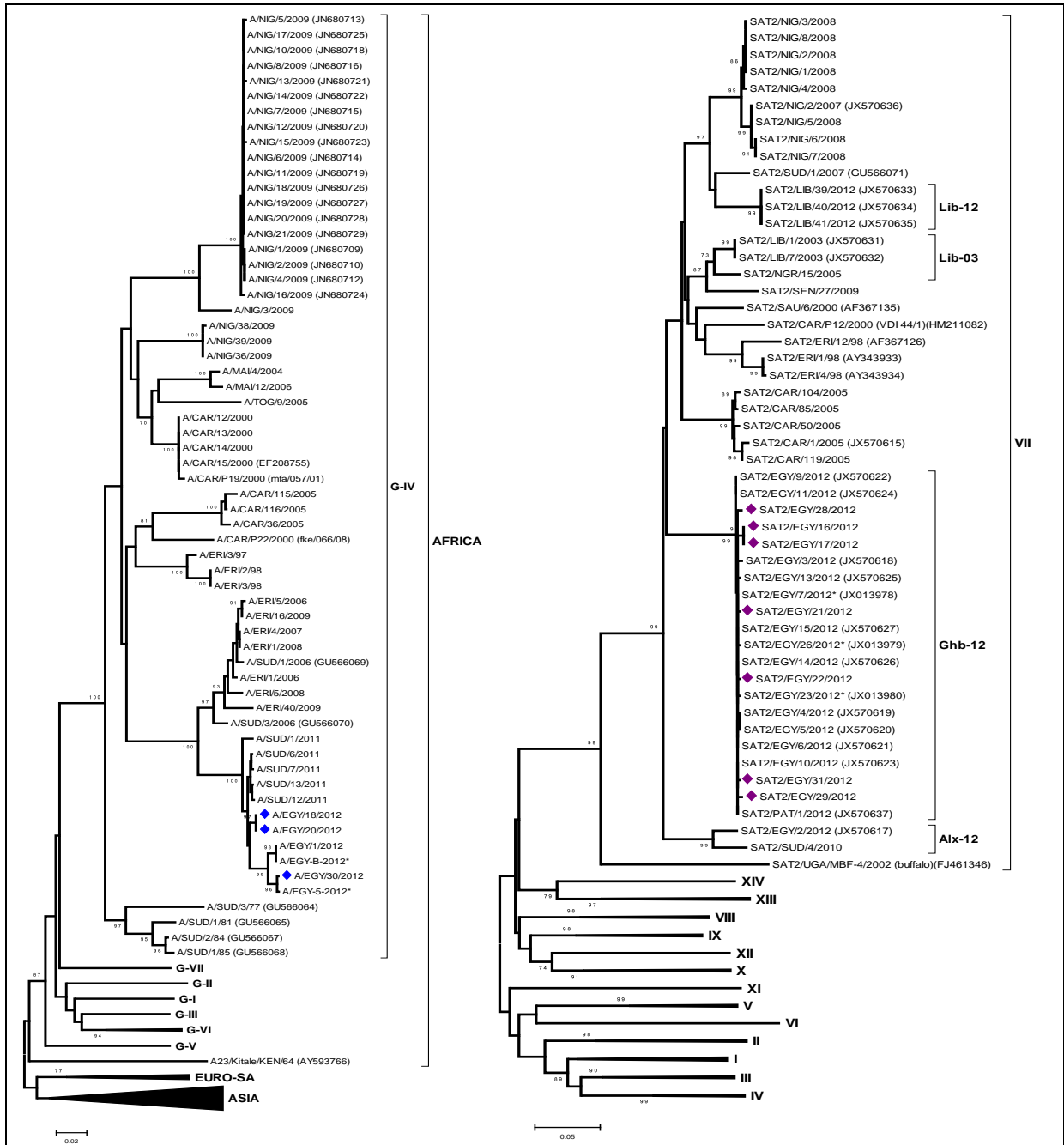
Date received: 28/09/2012

No. of samples: 21

SAT2/III: 21

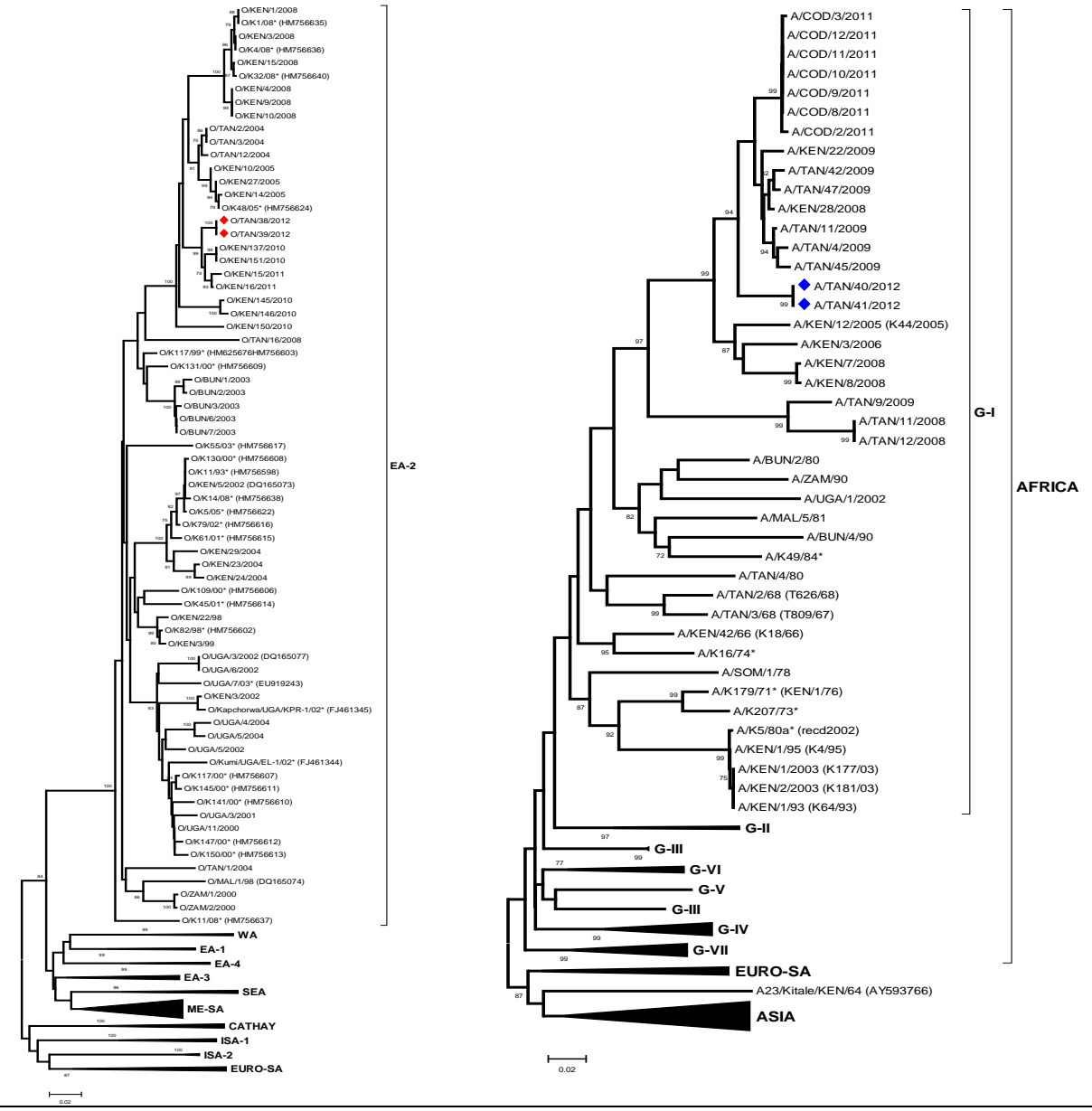
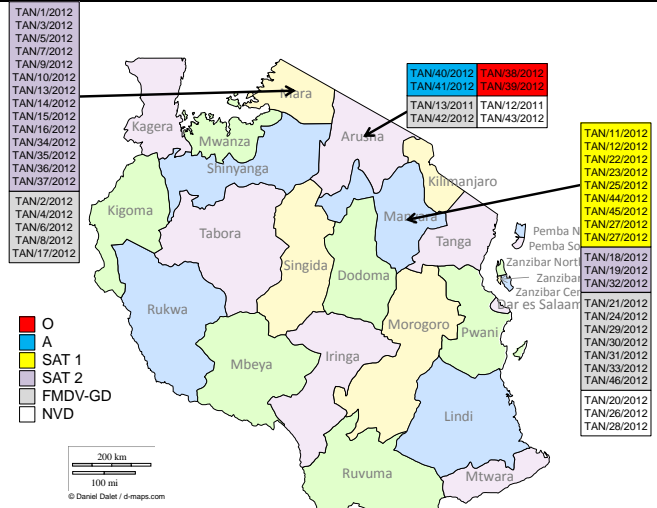


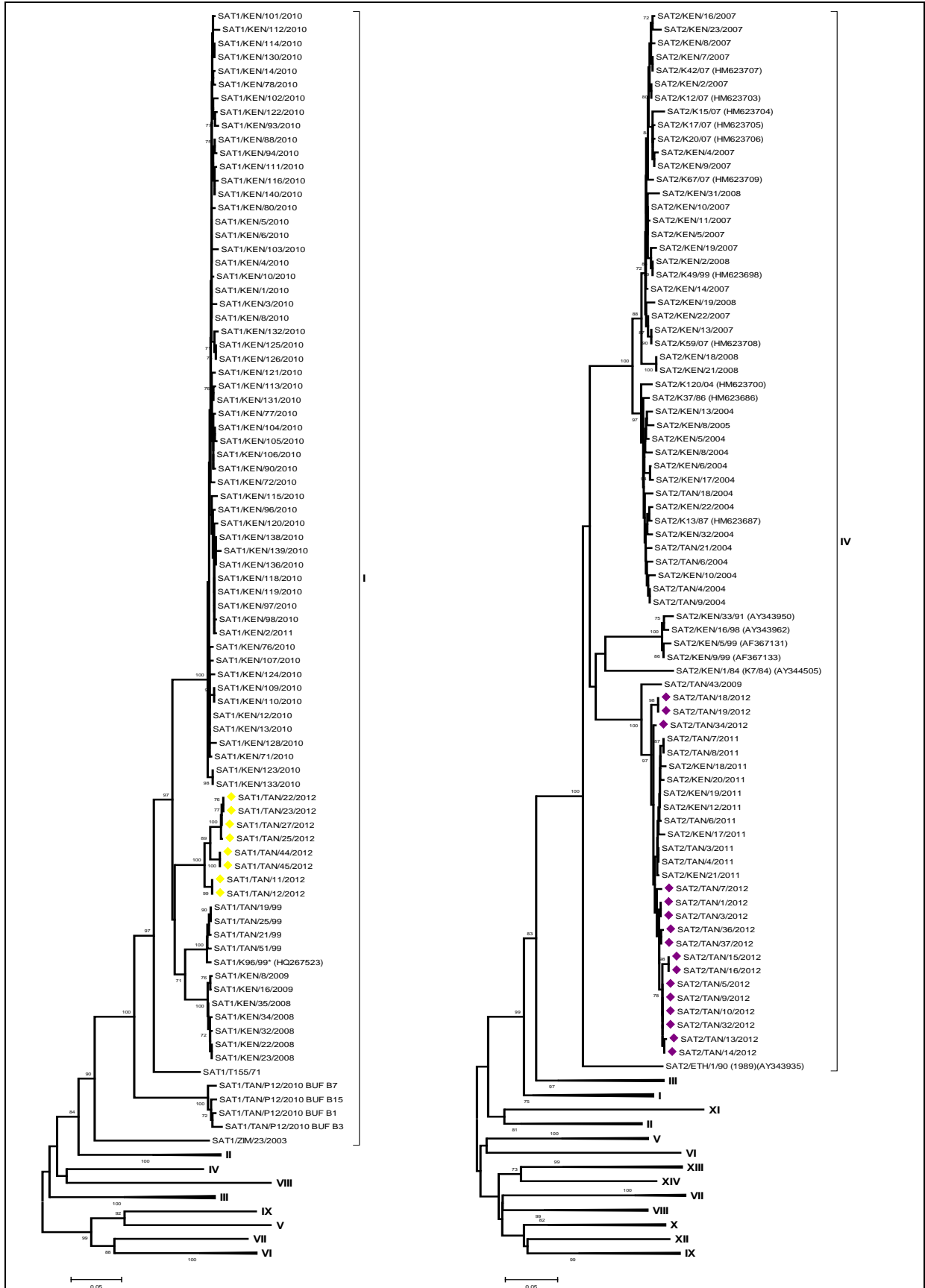




**Tanzania**

WRLFMD/2012/00031  
 Date received: 08/08/2012  
 No. of samples: 49  
 O/EA-2: 2  
 A/AFRICA/G-I: 2  
 SAT1/I: 9  
 SAT2/IV: 16  
 SAT2 (RT-PCR neg): 1  
 FMDV-GD: 14  
 NVD: 5





**Zambia**

WRLFMD/2012/00036

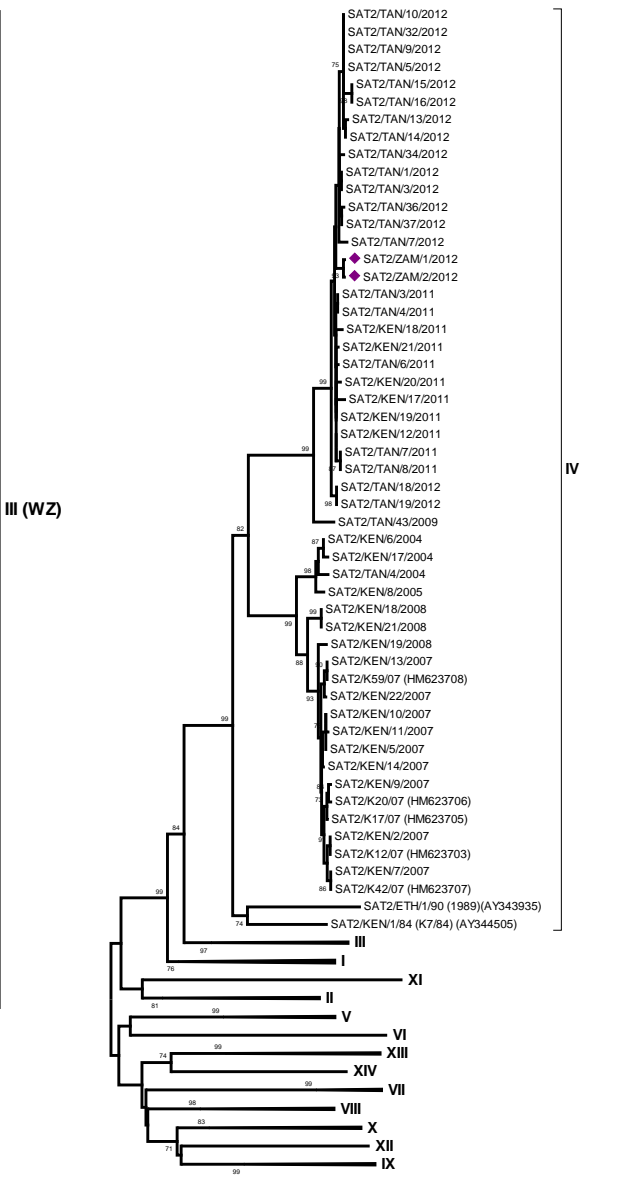
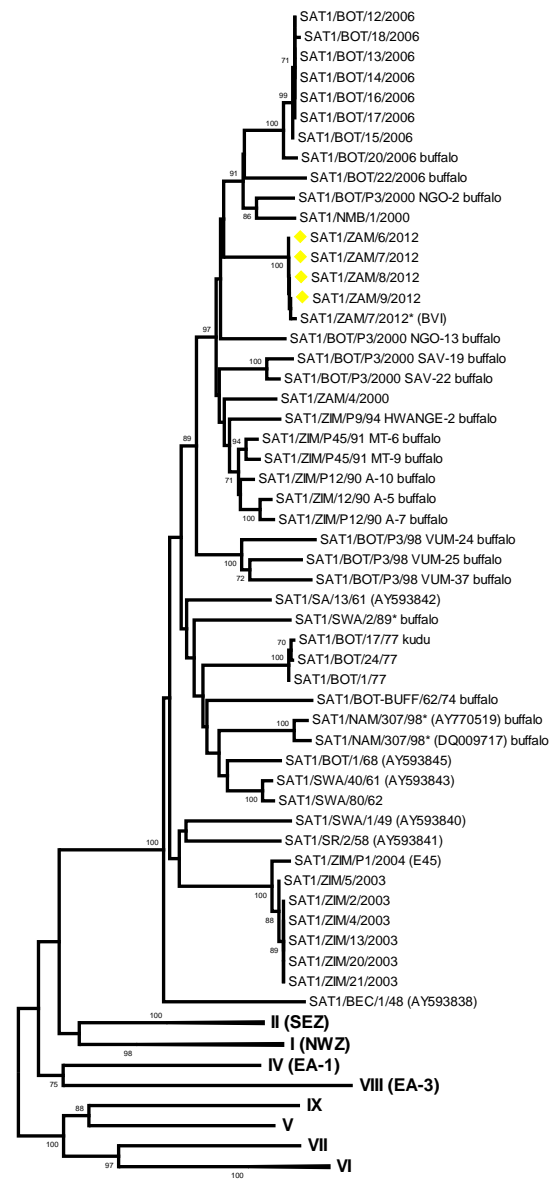
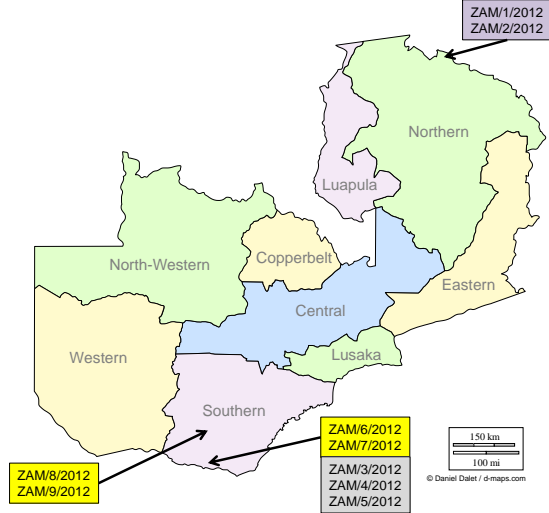
Date received: 28/09/2012

No. of samples: 9

SAT1/III: 4

SAT2/IV: 2

FMDV-GD: 3



## Vaccine matching

Twenty one FMDV type O isolates (See Table C, Type O for details) from Eritrea, Kenya, Egypt, Ethiopia, Iran, Turkey, Vietnam, Saudi Arabia, Sudan and Tanzania collected in 2011 and 2012 were analysed antigenically by the two dimensional virus neutralisation test (2dmVNT). All isolates from Saudi Arabia, Eritrea, Ethiopia, Iran and Sudan and one virus from Kenya were antigenically matched with O TUR 5/09. All isolates from Vietnam were antigenically matched with O 3039. Two viruses from Egypt and one virus from Tanzania showed no match with any of the vaccine strains against which they were tested (Table C).

Four FMDV type A viruses (See Table C, Type A for details) from Egypt and Sudan collected during 2011 and 2012 showed antigenic matching with A Eritrea and/or A TUR 06 vaccine strain by the 2dmVNT (Table C).

One FMDV type SAT 1 virus (see table C, Type SAT 1 for details) from Tanzania was antigenically matched with vaccine strain SAT 1 105 by the 2dmVNT (Table C).

One FMDV type SAT 2 virus (see table C, Type SAT 2 for details) from Tanzania was antigenically matched with both SAT 2 Eritrea and SAT 2 ZIM vaccine strains by the 2dmVNT (Table C).

## Annex 1.

**TABLE A: Clinical sample diagnosis made by the WRLFMD® between October-December 2012**

Country	WRL for FMD Sample Identification	Animal	Date of Collection	Results		
				VI/ELISA	RT-PCR	Final report
EGYPT	EGY 16/2012	BUFFALO	08-Mar-12	SAT 2	POS	SAT 2
	EGY 17/2012	BUFFALO	08-Mar-12	SAT 2	POS	SAT 2
	EGY 18/2012	CATTLE	09-Mar-12	A	POS	A
	EGY 19/2012	CATTLE	28-Feb-12	O	POS	O
	EGY 20/2012	CATTLE	09-Mar-12	A	POS	A
	EGY 21/2012	CATTLE	13-Mar-12	SAT 2	POS	SAT 2
	EGY 22/2012	CATTLE	13-Mar-12	SAT 2	POS	SAT 2
	EGY 23/2012	CATTLE	22-Mar-12	NT	POS	FMDV GD
	EGY 24/2012	CATTLE	02-Apr-12	NT	POS	FMDV GD
	EGY 25/2012	SHEEP	03-Apr-12	O	POS	O
	EGY 26/2012	SHEEP	25-Apr-12	O	POS	O
	EGY 27/2012	CATTLE	08-May-12	O	POS	O
	EGY 28/2012	CATTLE	17-May-12	SAT 2	POS	SAT 2
	EGY 29/2012	CATTLE	19-May-12	SAT 2	POS	SAT 2
	EGY 30/2012	CATTLE	19-May-12	A	POS	A
	EGY 31/2012	CATTLE	21-May-12	SAT 2	POS	SAT 2
	EGY 32/2012	CATTLE	22-May-12	NT	NT	NVD
	EGY 33/2012	BUFFALO	22-May-12	NT	NEG	NVD
	EGY 34/2012	CATTLE; BUFFALO	03-Jun-12	NT	NEG	NVD
	EGY 35/2012	CATTLE	04-Jul-12	NT	POS	FMDV GD
EGY 36/2012	CATTLE	05-Aug-12	NT	POS	FMDV GD	
PAKISTAN	PAK 9/2012	CATTLE	16-Jan-12	Pending	Pending	Pending
	PAK 10/2012	CATTLE	07-Feb-12	Pending	Pending	Pending
	PAK 11/2012	CATTLE	09-Feb-12	Pending	Pending	Pending
	PAK 12/2012	CATTLE	21-Feb-12	Pending	Pending	Pending

	PAK 13/2012	CATTLE	24-Feb-12	Pending	Pending	Pending
	PAK 14/2012	CATTLE	20-Mar-12	Pending	Pending	Pending
	PAK 15/2012	CATTLE	20-Mar-12	Pending	Pending	Pending
	PAK 16/2012	BUFFALO	06-Apr-12	Pending	Pending	Pending
	PAK 17/2012	CATTLE	07-Apr-12	Pending	Pending	Pending
	PAK 18/2012	BUFFALO	08-Apr-12	Pending	Pending	Pending
	PAK 19/2012	BUFFALO	08-Apr-12	Pending	Pending	Pending
	PAK 20/2012	CATTLE	11-Apr-12	Pending	Pending	Pending
	PAK 21/2012	CATTLE	12-Apr-12	Pending	Pending	Pending
	PAK 22/2012	CATTLE	26-Apr-12	Pending	Pending	Pending
	PAK 23/2012	CATTLE	27-Apr-12	Pending	Pending	Pending
	PAK 24/2012	CATTLE	27-Apr-12	Pending	Pending	Pending
	PAK 25/2012	CATTLE	27-Apr-12	Pending	Pending	Pending
	PAK 26/2012	CATTLE	27-Apr-12	Pending	Pending	Pending
	PAK 27/2012	CATTLE	08-May-12	Pending	Pending	Pending
	PAK 28/2012	CATTLE	09-May-12	Pending	Pending	Pending
	PAK 29/2012	BUFFALO	14-May-12	Pending	Pending	Pending
	PAK 30/2012	CATTLE	14-May-12	Pending	Pending	Pending
	PAK 31/2012	CATTLE	30-May-12	Pending	Pending	Pending
	PAK 32/2012	CATTLE	20-Jun-12	Pending	Pending	Pending
	PAK 33/2012	CATTLE	20-Jun-12	Pending	Pending	Pending
	PAK 34/2012	BUFFALO	21-Jun-12	Pending	Pending	Pending
	PAK 35/2012	BUFFALO	21-Jun-12	Pending	Pending	Pending
	PAK 36/2012	BUFFALO	30-Jun-12	Pending	Pending	Pending
	PAK 37/2012	BUFFALO	30-Jun-12	Pending	Pending	Pending
	PAK 38/2012	CATTLE	28-Sep-12	Pending	Pending	Pending
	PAK 39/2012	CATTLE	05-Nov-12	Pending	Pending	Pending
	PAK 40/2012	CATTLE	23-Nov-12	Pending	Pending	Pending
	PAK 41/2012	CATTLE	23-Nov-12	Pending	Pending	Pending
SRI LANKA	SRL 3/2009	BOVINE	09-Sep-09	O	POS	O
	SRL 2/2010	BOVINE	13-Jan-10	NEG	POS	FMDV GD
	SRL 3/2010	BOVINE	13-Jan-10	O	POS	O
	SRL 4/2010	SWINE	18-Jan-10	NEG	NEG	NVD
	SRL 5/2010	BOVINE	15-Feb-10	NEG	POS	FMDV GD
	SRL 6/2010	BOVINE	31-Mar-10	NEG	POS	FMDV GD
	SRL 7/2010	BOVINE	31-Mar-10	NEG	NEG	NVD
	SRL 8/2010	BOVINE	21-Apr-10	O	POS	O
	SRL 9/2010	BUFFALO	21-Apr-10	O	POS	O
	SRL 10/2010	BOVINE	02-Jun-10	NEG	NEG	NVD
	SRL 11/2010	BOVINE	04-Jun-10	NEG	POS	FMDV GD
	SRL 12/2010	BOVINE	09-Jun-10	NEG	NEG	NVD
	SRL 13/2010	BOVINE	02-Dec-10	O	POS	O
	SRL 2/2011	BOVINE	03-Jun-11	NEG	NEG	NVD
	SRL 1/2012	BOVINE	14-Mar-12	NEG	POS	FMDV GD
	SRL 2/2012	BOVINE	15-Jun-12	O	POS	O
VIETNAM, SOCIALIST REPUBLIC OF	VIT 14/2012	PIG	16-Apr-12	O	POS	O
	VIT 15/2012	PIG	16-Oct-12	A	POS	A
	VIT 16/2012	PIG	16-Oct-12	A	POS	A
	VIT 17/2012	PIG	16-Oct-12	A	POS	A
	VIT 18/2012	PIG	16-Oct-12	A	POS	A
	VIT 19/2012	PIG	16-Oct-12	A	POS	A
	VIT 20/2012	PIG	16-Oct-12	A	POS	A



VIT 21/2012	PIG	05-Nov-12	O	POS	O
VIT 22/2012	PIG	05-Nov-12	O	POS	O
<b>TOTAL :</b>	<b>79</b>				

FMD(V)	Foot-and-mouth disease (virus)
FMDV GD	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
NT	Not tested

**TABLE B: Summary of samples collected and received to The Pirbright Institute (October-December 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			
EGYPT	21	4	3	-	-	7	-	-	7	18	2
PAKISTAN	33	-	-	-	-	-	-	-	-	-	-
SRI LANKA	16	6	-	-	-	-	-	-	10	11	5
VIETNAM, SOCIALIST REPUBLIC OF	9	3	6	-	-	-	-	-	-	9	-
<b>TOTAL</b>	<b>79</b>	<b>13</b>	<b>9</b>	<b>-</b>	<b>-</b>	<b>7</b>	<b>-</b>	<b>-</b>	<b>17</b>	<b>38</b>	<b>7</b>

VI/ELISA	FMD (or SVD) virus serotype identified following virus isolation in cell culture and antigen detection ELISA
FMD	foot-and-mouth disease
SVD	swine vesicular disease
NVD	no FMD, SVD or vesicular stomatitis virus detected
NT	not tested
RT-PCR	reverse transcription polymerase chain reaction for FMD (or SVD) viral genome

**TABLE C:** Antigenic characterisation of FMD field isolates by matching with vaccine strains by 2dmVNT from 1<sup>st</sup> October to 31<sup>st</sup> December 2012**Type O:****Vaccine Matching studies for serotype O FMDV by VNT-WRLFMD®**

SAMPLE REF	O 3039	O 4625	O Manisa	O Tur 5/09	O Campos
VIT 13/2012	M		M		
VIT 2/2012	M		N		
VIT 7/2012	M		M		
VIT 8/2012	M		M		
SAU 1/2012		M	N	M	
SAU 4/2012		M	M	M	
ERI 1/2011		M	N	M	
ERI 18/2011		M	N	M	
ERI 3/2011		M	N	M	
VIT 22/2012	M		M		
O KEN 6/11		M	N	M	
O KEN 11/11		M	N	N	
O EGY 19/12		N	N	N	N
O EGY 27/12		N	N	N	N
O TAN38/12		N	N	N	
O ETH29/2011		N	M	M	
O ETH 4/12		N	N	M	
O ETH 7/12		N	N	M	
O ETH 12/11		M	M	M	
O IRN 13/12		M	N	M	
O IRN 21/12		N	M	M	

**Type A:****Vaccine Matching studies for serotype A FMDV by VNT-WRLFMD®**

SAMPLE REF	A Eritrea	A Iran 2005	A SAU 41/91	A SAU 95	A TUR 06	A22 IRQ
SUD 6/2011	N	N	N	N	M	N
SUD13/2011	M	N	N	N	N	N
EGY 18/2012	M	N		N	M	N
EGY 30/2012	M	N		N	M	N

**Type SAT 1:****Vaccine Matching studies for serotype SAT 1 FMDV by VNT-WRLFMD®**

SAMPLE REF	SAT 1 105
SAT 1 TAN 11/12	M

**TYPE SAT 2:****Vaccine Matching studies for serotype SAT 2 FMDV by VNT-WRLFMD®**

SAMPLE REF	SAT 2 Eritrea	SAT 2 ZIM
SAT2 SUD 4/10	M	M

**Results Descriptor:**

**M** : = Vaccine Match-  $r_1 = \geq 0.3$ . 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** : = No Vaccine Match -  $r_1 = < 0.3$ . Suggests that the field isolate is so different from the vaccine strain that the vaccine is unlikely to protect

= Not tested against this vaccine

**Annex 2. Recent FMD Publications cited by PubMed**

1. Jung S, Schlick T. Candidate RNA structures for domain 3 of the foot-and-mouth-disease virus internal ribosome entry site. *Nucleic Acids Res.* 2012 Dec 28. [Epub ahead of print] PubMed PMID: 23275533.
2. Dar PA, Suryanaryana VS, Nagarajan G, Reddy GR, Dechamma HJ, Kondabattula G. DNA prime-protein boost strategy with replicase-based DNA vaccine against foot-and-mouth disease in bovine calves. *Vet Microbiol.* 2012 Dec 25. doi:pii: S0378-1135(12)00695-5. 10.1016/j.vetmic.2012.12.017. [Epub ahead of print] PubMed PMID: 23305616.
3. Zhou G, Wang H, Wang F, Yu L. Recombinant adenovirus expressing type Asia1 foot-and-mouth disease virus capsid proteins induces protective immunity against homologous virus challenge in mice. *Res Vet Sci.* 2012 Dec 22. doi:pii:S0034-5288(12)00356-6. 10.1016/j.rvsc.2012.12.004. [Epub ahead of print] PubMed PMID: 23267820.
4. Molin-Capeti KC, Sepulveda L, Terra F, Torres-Pioli MF, Costa-Casagrande T, França SC, Thomaz-Soccol V. A proposal for an alternative quality control test procedure for inactivated vaccines against food-and-mouth disease virus. *Vaccine.* 2012 Dec 22. doi:pii: S0264-410X(12)01753-7. 10.1016/j.vaccine.2012.12.001. [Epub ahead of print] PubMed PMID: 23267841.
5. Pega J, Bucafusco D, Di Giacomo S, Schammas J, Malacari D, Capozzo A, Arzt J, Pérez-Beascochea C, Maradei E, Rodríguez L, Borca M, Pérez-Filgueira M. Early Adaptive Immune Responses in the Respiratory Tract of Foot and Mouth Disease-Infected Cattle. *J Virol.* 2012 Dec 19. [Epub ahead of print] PubMed PMID:23255811.
6. Legesse Y, Asfaw Y, Sahle M, Ayelet G, Jenberie S, Negussie H. First confirmation of foot and mouth disease virus serotype SAT-1 in cattle and small ruminants in Ethiopia in 2007/08. *Trop Anim Health Prod.* 2012 Dec 19. [Epub ahead of print] PubMed PMID: 23250672.
7. Basagoudanavar SH, Hosamani M, Tamil Selvan RP, Sreenivasa BP, Saravanan P, Chandrasekhar Sagar BK, Venkataramanan R. Development of a liquid-phase blocking ELISA based on foot-and-mouth disease virus empty capsid antigen for seromonitoring vaccinated animals. *Arch Virol.* 2012 Dec 16. [Epub ahead of print] PubMed PMID: 23242775.
8. Arias A, de Avila AI, Sanz-Ramos M, Agudo R, Escarmis C, Domingo E. Molecular dissection of a viral quasispecies under mutagenic treatment: positive correlation between fitness loss and mutational load. *J Gen Virol.* 2012 Dec 12. [Epub ahead of print] PubMed PMID: 23239576.

9. Cao Y, Lu Z, Li Y, Sun P, Li D, Li P, Bai X, Fu Y, Bao H, Zhou C, Xie B, Chen Y, Liu Z. Poly(I:C) combined with multi-epitope protein vaccine completely protects against virulent foot-and-mouth disease virus challenge in pigs. *Antiviral Res.* 2012 Dec 7;97(2):145-153. doi: 10.1016/j.antiviral.2012.11.009. [Epub ahead of print] PubMed PMID: 23219974.
10. Zhou JH, Gao ZL, Zhang J, Ding YZ, Stipkovits L, Szathmary S, Pejsak Z, Liu YS. The analysis of codon bias of foot-and-mouth disease virus and the adaptation of this virus to the hosts. *Infect Genet Evol.* 2012 Dec 4;14C:105-110. doi: 10.1016/j.meegid.2012.09.020. [Epub ahead of print] PubMed PMID: 23220329.
11. 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 Dec;96(3):288-95. doi: 10.1016/j.antiviral.2012.09.019. Epub 2012 Oct 6. PubMed PMID: 23043941.
12. Sun YF, Lin Y, Zhang JH, Zheng SP, Ye YR, Liang XX, Han SY. Double Candida antarctica lipase B co-display on Pichia pastoris cell surface based on a self-processing foot-and-mouth disease virus 2A peptide. *Appl Microbiol Biotechnol.* 2012 Dec;96(6):1539-50. doi: 10.1007/s00253-012-4264-0. Epub 2012 Jul 14. PubMed PMID: 22797600.
13. Chen HT, Peng YH, Zhang YG, Liu XT. Detection of Foot-and-mouth Disease Serotype O by ELISA Using a Monoclonal Antibody. *Hybridoma (Larchmt).* 2012 Dec;31(6):462-4. doi: 10.1089/hyb.2012.0081. PubMed PMID: 23244327; PubMed Central PMCID: PMC3526892.
14. Berryman S, Brooks E, Burman A, Hawes P, Roberts R, Netherton C, Monaghan P, Whelband M, Cottam E, Elazar Z, Jackson T, Wileman T. Foot-and-mouth disease virus induces autophagosomes during cell entry via a class III phosphatidylinositol 3-kinase-independent pathway. *J Virol.* 2012 Dec;86(23):12940-53. doi: 10.1128/JVI.00846-12. Epub 2012 Sep 19. PubMed PMID: 22993157; PubMed Central PMCID: PMC3497631.
15. 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 Dec;59(6):476-81. doi: 10.1111/tbed.12015. Epub 2012 Oct 1. PubMed PMID: 23025522.
16. Rashtibaf M, Sharifi K, Zibae S, Dehghani H. A survey on the frequency of foot-and-mouth disease virus carriers in cattle in north-east of Iran by RT-PCR: implications for revising disease control strategy. *Transbound Emerg Dis.* 2012 Dec;59(6):482-9. doi: 10.1111/j.1865-1682.2011.01299.x. Epub 2012 Jan 4. PubMed PMID: 22222047.
17. 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 Dec;170(1-2):59-65. doi:10.1016/j.virusres.2012.08.018. Epub 2012 Sep 2. PubMed PMID: 22974759.
18. Grazioli S, Fallacara F, Brocchi E. Mapping of antigenic sites of Foot-and-Mouth Disease virus serotype Asia 1 and relationships with sites described in other serotypes. *J Gen Virol.* 2012 Nov 28. [Epub ahead of print] PubMed PMID: 23197575.
19. Porta C, Xu X, Loureiro S, Paramasivam S, Ren J, Al-Khalil T, Burman A, Jackson T, Belsham GJ, Curry S, Lomonosoff GP, Parida S, Paton D, Li Y, Wilsden G, Ferris N, Owens R, Kotecha A, Fry E, Stuart DI, Charleston B, Jones IM. Efficient production of foot-and-mouth disease virus empty capsids in insect cells following down regulation of 3C protease activity. *J Virol Methods.* 2012 Nov 19. doi:pii: S0166-0934(12)00391-6. 10.1016/j.jviromet.2012.11.011. [Epub ahead of print] PubMed PMID: 23174161.
20. Park JH, Lee KN, Ko YJ, Kim SM, Lee HS, Park JY, Yeh JY, Kim MJ, Lee YH, Sohn HJ, Moon JS, Cho IS, Kim B. Outbreaks and Diagnosis of Foot-and-Mouth Disease Serotype O in the Republic of Korea, April-June 2010. *Transbound Emerg Dis.* 2012 Nov 19. doi: 10.1111/tbed.12029. [Epub ahead of print] PubMed PMID: 23164336.
21. Kandeil A, El-Shesheny R, Kayali G, Moatasim Y, Bagato O, Darwish M, Gaffar A, Younes A, Farag T, Kutkat MA, Ali MA. Characterization of the recent outbreak of foot-and-mouth disease virus serotype SAT2 in Egypt. *Arch Virol.* 2012 Nov 7. [Epub ahead of print] PubMed PMID: 23132412.

22. Lavoria MÁ, 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 Nov 6;30(48):6845-50. doi: 10.1016/j.vaccine.2012.09.011. Epub 2012 Sep 18. PubMed PMID: 23000129.
23. 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- $\alpha$  and antiviral agents. *Antiviral Res*. 2012 Nov;96(2):213-20. doi:10.1016/j.antiviral.2012.09.009. Epub 2012 Sep 21. PubMed PMID: 23000495.
24. 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 Nov;40(6):426-30. doi: 10.1016/j.biologicals.2012.08.002. Epub 2012 Oct 16. PubMed PMID: 23084588.
25. Maier P, Heckmann D, Spier I, Laufs S, Zucknick M, Allgayer H, Fruehauf S, Zeller WJ, Wenz F. F2A sequence linking MGMT(P140K) and MDR1 in a bicistronic lentiviral vector enables efficient chemoprotection of haematopoietic stem cells. *Cancer Gene Ther*. 2012 Nov;19(11):802-10. doi: 10.1038/cgt.2012.67. Epub 2012 Oct 5. PubMed PMID: 23037811.
26. Vázquez-Calvo A, Caridi F, Rodríguez-Pulido M, Borrego B, Sáiz M, Sobrino F, Martín-Acebes MA. Modulation of foot-and-mouth disease virus pH threshold for uncoating correlates with differential sensitivity to inhibition of cellular Rab GTPases and decreases infectivity in vivo. *J Gen Virol*. 2012 Nov;93(Pt 11):2382-6. doi: 10.1099/vir.0.045419-0. Epub 2012 Aug 8. PubMed PMID: 22875255.
27. 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.
28. 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; PubMed Central PMCID: PMC3486479.
29. 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; PubMed Central PMCID: PMC3486329.
30. Morelli MJ, Thébaud G, Chadœuf J, King DP, Haydon DT, Soubeyrand S. A bayesian inference framework to reconstruct transmission trees using epidemiological and genetic data. *PLoS Comput Biol*. 2012 Nov;8(11):e1002768. doi:10.1371/journal.pcbi.1002768. Epub 2012 Nov 15. PubMed PMID: 23166481; PubMed Central PMCID: PMC3499255.
31. Cho JG, Jo YJ, Sung JH, Hong JK, Hwang JH, Park JH, Lee KN, Park SG. Monoclonal and polyclonal antibodies specific for foot and mouth disease virus type A and type O VP1. *Hybridoma (Larchmt)*. 2012 Oct;31(5):358-63. doi:10.1089/hyb.2012.0034. PubMed PMID: 23098303; PubMed Central PMCID: PMC3482373.
32. Dias CC, Moraes MP, Weiss M, Diaz-San Segundo F, Perez-Martin E, Salazar AM, de los Santos T, 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.
33. 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.
34. 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. doi: 10.1016/j.jviromet.2012.03.036. Epub 2012 Jul 2. PubMed PMID: 22766183.

35. 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.
36. 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.
37. 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.
38. 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.
39. 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.

## Annex 3. RECOMMENDATIONS FROM WRLFMD® ON FMD VIRUS STRAINS TO BE INCLUDED IN FMDV ANTIGEN BANKS – December 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)

