WRLFMD Quarterly Report July-September 2013

Reference Laboratory Contract Report

This page deliberately blank

Reference Laboratory Contract Report[1,2] July-September 2013

Foot-and-Mouth Disease

[1]N.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. Donald King, The Pirbright Institute, donald.king@pirbright.ac.uk.

[2] Copies of all the individual reports cited herein can be obtained from Dr. Donald King, The Pirbright Institute, donald.king@pirbright.ac.uk.

Summary

ASIA
PR China

Between 5th July and 5th September 2013, five outbreaks of **FMD type A** were reported in cattle and pigs in the Tibet Autonomous Region (outbreaks had previously been reported in April and May 2013). On 22nd July and 5th August 2013 two outbreaks due to **FMD type O** were also reported in cattle in Tibet (last occurrence was in June 2013). On 24th September, a single outbreak of **FMD type A** was reported in cattle in the Xinjiang Uyghur Autonomous Region (last occurrence in April and May 2013). No recent genotyping has been reported.

Kazakhstan

Two VP1 sequences were received from ARRIAH on 31/07/2013. These **FMD type A** viruses were isolated from samples taken from cattle at Akshoky, Urdzharsky, East Kazakhstan on 9th May 2013. Phylogenetic analysis (see below) showed that they belonged to the ASIA topotype, Sea-97 lineage and were closely related to viruses from Thailand, Vietnam, P.R. China, Eastern Russia and western Mongolia.

Mongolia

On the 4th and 6th July 2013, two outbreaks of **FMD type A** were reported in cattle, sheep and goats in Bayan-Ölgii Province (western Mongolia). VP1 sequencing at both ARRIAH and WRLFMD confirmed the virus to belong to the ASIA topotype, Sea-97 lineage. The Mongolian viruses [which were isolated from yaks (*Bos grunniens*) on the 3rd to 5th July] were closely related to recent virus isolates from Kazakhstan, eastern Russia, P.R China, Vietnam and Thailand (see below). Subsequently, on the 18th September an outbreak of **FMD type A** was reported in cattle in Dornod Province (eastern Mongolia); no genotyping has yet been reported.

Russian Federation

On 4th July 2013 a single outbreak of **FMD type A** was reported in cattle in the Kabardino-Balkaria Republic (North Caucasus). VP1 sequencing was performed at ARRIAH and analysed at the WRLFMD confirming that the virus belonged to the ASIA topotype, Iran-05 lineage, SIS-10 sublineage (closely related to viruses which had occurred in June 2013 in the North Caucasus area of Russia) (see below).

Between 8th August and 28th September 2013, eight outbreaks of **FMD type A** were reported in cattle and pigs in the Amur Oblast and Zabaykalsky Krai regions of eastern Russia. VP1 sequencing was performed at ARRIAH and analysed at the WRLFMD confirming that the viruses to belong to the ASIA topotype, Sea-97 lineage and were closely related to virus isolates from Kazakhstan, Mongolia, P.R China, Vietnam and Thailand (see below).

Vietnam

Two **FMD type A** viruses were isolated from probang samples collected from in cattle in Nghe An province (North Central Coast region) in November 2012. Genotyping performed in the WRLFMD showed these viruses to belong to the ASIA topotype, Sea-97 lineage and to be closely related to viruses from Thailand in 2012 and P.R China, Russian Federation, Kazakhstan and Mongolia in 2013 (see below).

FMD type O viruses were isolated from samples taken from cattle in Nghe An, Quang Nam, Ninh Thuan and Phu Yen provinces in 2012 and 2013. VP1 genotyping at WRLFMD showed them to belong to the ME-SA topotype, PanAsia lineage which is endemic in Southeast Asia (see below).

AFRICA
Libya

Between 15th August and 7th September 2013, 12 outbreaks of **FMD type O** were reported in cattle, sheep and goats in the Jafara, Misrata, Nuqat al Khams and Zliten districts in north-western Libya. No genotyping has been performed.

Namibia

Between 4th and 13th August 2013, three outbreaks of FMD were reported in cattle in the Caprivi Strip. The serotype involved has not yet been determined. The outbreak has occurred in the FMD-infected zone where there are free-living African buffalo. This event was outside the officially recognized free zone and does not change the FMD free zone status of Namibia.

South Africa

Between 17th July and 4th August 2013, four outbreaks of **FMD type SAT 1** were reported in cattle adjacent to the Kruger National Park in the Limpopo province (Greater Giyani and Ba-Phalaborwa). Subsequently, on 6th August 2013, an outbreak of **FMD type SAT 2** was reported in cattle in Bushbuckridge, Mpumalanga province. Both occurred within South Africa's FMD protection zone where vaccination for FMD is performed. Genotyping results are awaited.

Zimbabwe

Three further outbreaks have been reported in cattle in Zaka (Masvingo province; 26th June and 23rd July 2013) and Chipinge (Manicaland province; 10th July 2013) following earlier outbreaks in these two provinces during April and May. The FMD serotype involved has not yet been determined.

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/2013.htm.

WRLFMD vaccine recommendations have been changed: serotype A vaccines (A Iran 87, A Iran 96 and A Iran 99) have been moved to low priority reflecting the epidemiology of serotype A viruses in the Middle East (Annex 3).

Summary of sequencing data

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 2013 is shown in Annex 1 Table A. A summary of these results is shown in Annex 1 Table B.

Table 1: Status of sequencing of samples received by the WRLFMD from July to September 2013.

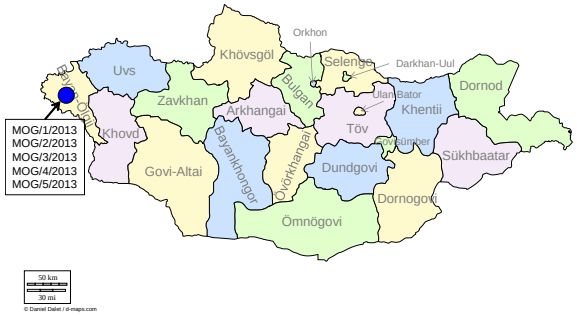
Batch	Date Recd.	Country	Serotype	No. of samples	No. of sequences	Status
WRLFMD/2013/00017	16/08/2013	Vietnam	O	9	9	Completed
			A	2	2	Completed
WRLFMD/2013/00018	19/08/2013	Mongolia	A	5	5	Completed
WRLFMD/2013/00019	25/09/2013	Kenya		10	10	In progress
Total				26	26	

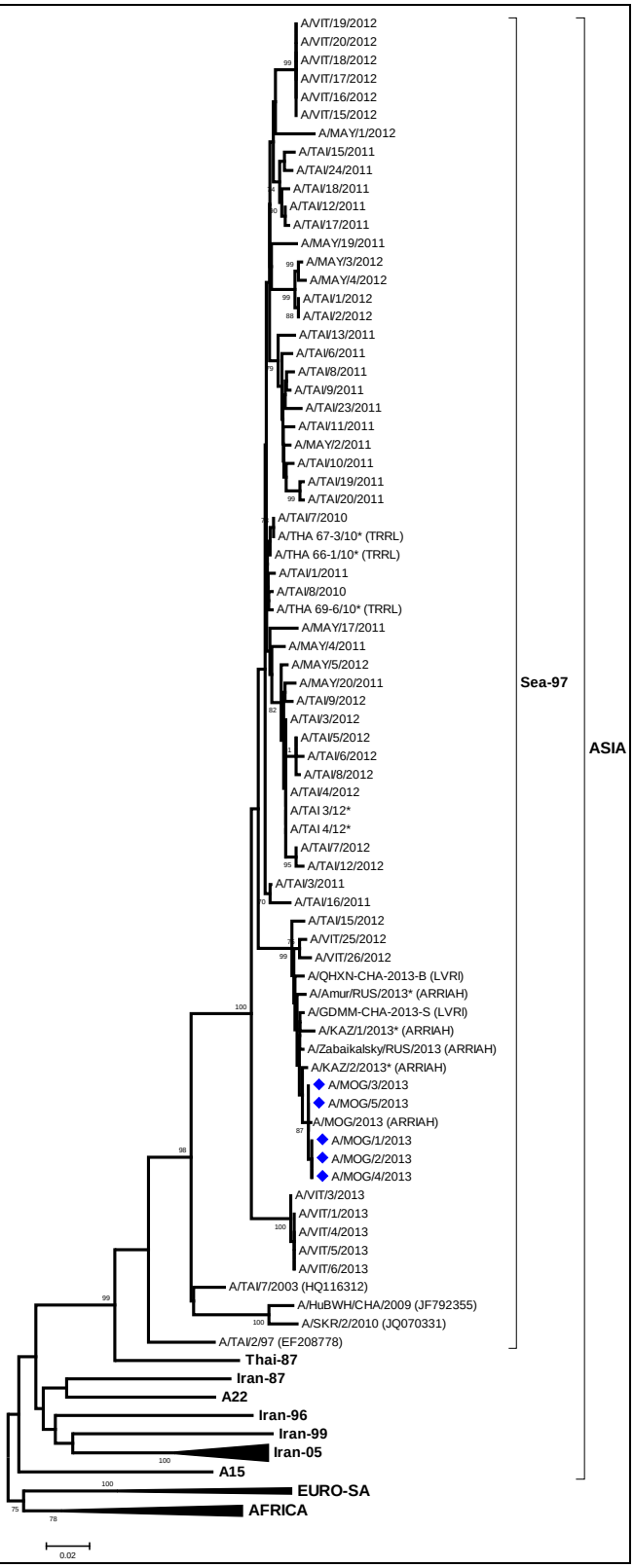
Detailed Analysis:

ASIA

Mongolia

WRLFMD/2013/00018
Date received: 19/08/2013
No. of samples: 10
A (ASIA/Sea-97): 5
NVD: 5



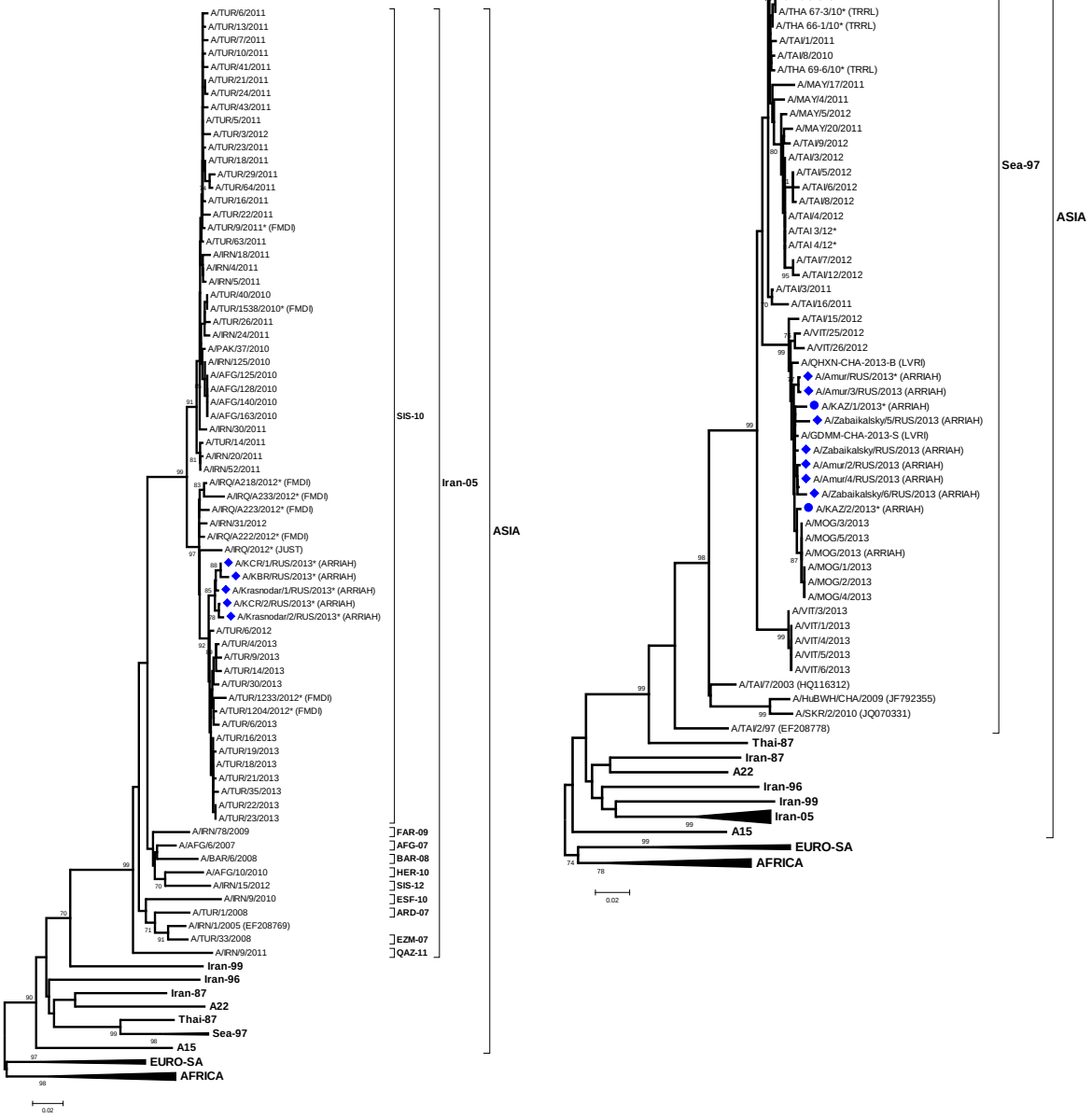


Russian Federation

VP1 sequences received from ARRIAH
Date received: 31/07/2013, 21/08/2013 & 26/09/2013
No. of sequences: 11
A (ASIA/Sea-97): 6
A (ASIA/Iran-05^{SIS-10}): 5

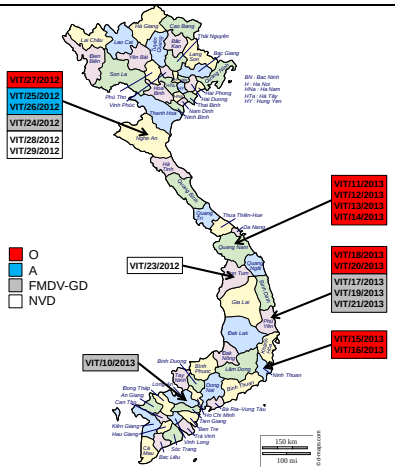
Kazakhstan

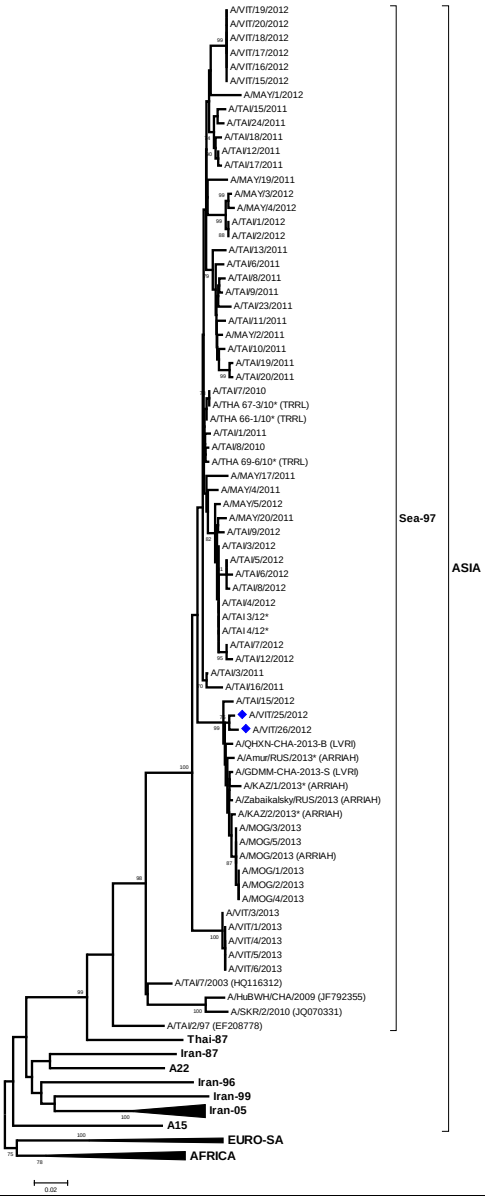
VP1 sequences received from ARRIAH
Date received: 31/07/2013
No. of sequences: 2
A (ASIA/Sea-97): 2

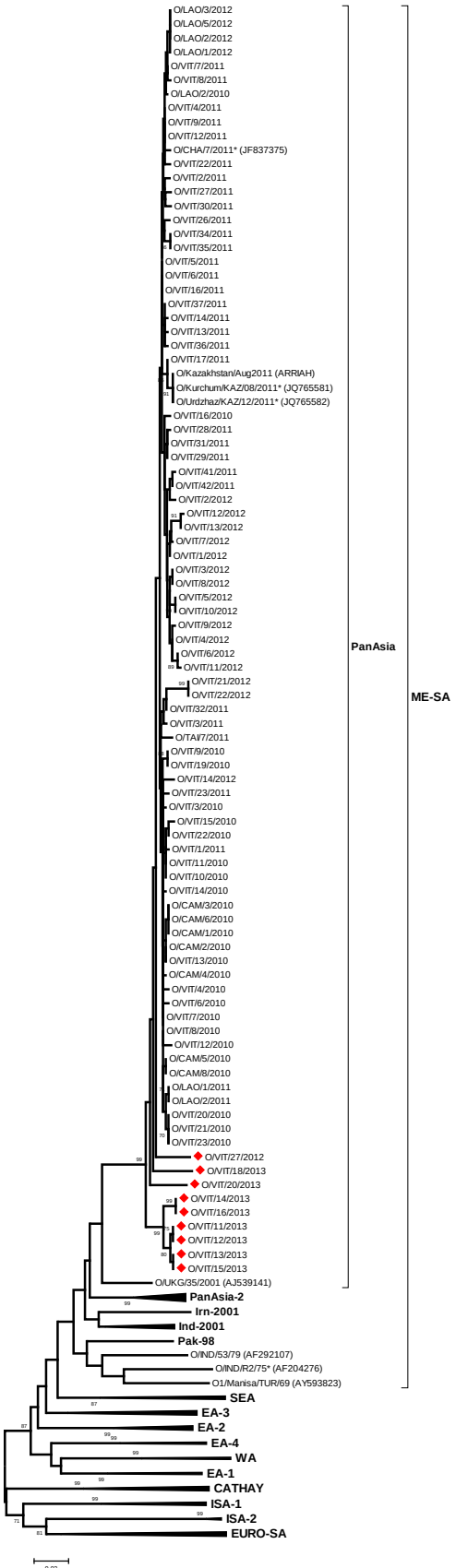


Vietnam

WRLFMD/2013/00017
Date received:
16/08/2013
No. of samples: 19
O (ME-SA/PanAsia): 9
A (ASIA/Sea-97): 2
FMDV-GD: 5
NVD: 3







Vaccine matching

Serotype O
Nine FMDV type O isolates (see Table C, type O for details) from Southeast Asian countries (Vietnam, Thailand, Laos and Cambodia) collected in 2012 and 2013 were analysed using the two dimensional neutralisation test (2 dm VNT). These samples represent three serotype O topotypes and strains: O/ME-SA/PanAsia (O/VIT/11/2013, O/VIT18/2013, O/LAO/1/2012, O/LAO/5/2012, O/CAM/1/2012, O/CAM/2/2102); O/CATHAY (O/TAI/19/2012) and O/SEA/Mya-98 (O/TAI/14/2012, O/TAI/1/2013). Most (8/9) of these isolates matched with O3039 and O TAW/98, although fewer were matched with O Manisa and O TUR 5/09 (3/9 and 7/9, respectively).

A recent serotype O isolate collected from Bhutan in 2013 representative of the O/ME-SA/Ind-2001 lineage matched with O 3039, O Taw/98 and O TUR 5/09.

Four additional isolates from Turkey (collected during 2013) matched with the O TUR 5/09 vaccine and O 4625 (only three isolates tested).

Serotype A
Two FMDV type A isolates (see Table C, type A for details) from Mongolia collected in 2013 were analysed using the two dimensional neutralisation test (2 dm VNT). Both isolates showed antigen match with A/IRN/2005, A22/IRQ and A/TUR/2006 but did not match with A MAY/97. These results can be compared to data generated for related serotype A viruses from the A/ASIA/Sea-97 lineage collected from Thailand during 2012 and 2013 which generally also showed poor match in the 2 dm VNT to the A MAY/97 vaccine as well as other vaccines in the panel.

Annex 1.
TABLE A: Clinical sample diagnostics made by the WRLFMD® between July-September 2013

Country	WRL for FMD Sample Identification	Animal	Date of Collection	Results VI/ ELISA	Results RT-PCR	Final report
KENYA	KEN 126/2009	CATTLE	00-00-09	Pending	Pending	Pending
	KEN 4/2012	CATTLE	00-00-12	Pending	Pending	Pending
	KEN 5/2012	CATTLE	23-Dec-12	Pending	Pending	Pending
	KEN 6/2012	CATTLE	24-Dec-12	Pending	Pending	Pending
	KEN7/2012	CATTLE	29-Dec-12	Pending	Pending	Pending
	KEN 1/2013	CATTLE	00-00-13	Pending	Pending	Pending
	KEN 2/2013	CATTLE	15-Jan-13	Pending	Pending	Pending
	KEN 3/2013	CATTLE	15-Jan-13	Pending	Pending	Pending
	KEN 4/2013	CATTLE	20-Jan-13	Pending	Pending	Pending
	KEN 5/2013	CATTLE	20-Jan-13	Pending	Pending	Pending
	KEN 6/2013	CATTLE	22-Jan-13	Pending	Pending	Pending
	KEN 7/2013	CATTLE	22-Jan-13	Pending	Pending	Pending
	KEN 8/2013	CATTLE	22-Jan-13	Pending	Pending	Pending
	KEN 9/2013	CATTLE	28-Jan-13	Pending	Pending	Pending
	KEN 10/2013	CATTLE	30-Jan-13	Pending	Pending	Pending
MONGOLIA	MOG 1/2013	YAK	03-Jul-13	A	POS	A
	MOG 2/2013	YAK	03-Jul-13	A	NEG	A
	MOG 3/2013	YAK	03-Jul-13	A	POS	A
	MOG 4/2013	YAK	05-Jul-13	A	POS	A
	MOG 5/2013	YAK	05-Jul-13	A	NEG	A
	MOG 6/2013	YAK	05-Jul-13	NVD	NEG	NVD
	MOG 7/2013	YAK	05-Jul-13	NVD	NEG	NVD
	MOG 8/2013	YAK	05-Jul-13	NVD	NEG	NVD
	MOG 9/2013	YAK	05-Jul-13	NVD	NEG	NVD
	MOG 10/2013	YAK	05-Jul-13	NVD	NEG	NVD
VIETNAM, SOCIALIST REPUBLIC OF	VIT 23/2012	CATTLE	10-Nov-12	NVD	NEG	NVD
	VIT 24/2012	CATTLE	10-Nov-12	NVD	POS	FMDV GD
	VIT 25/2012	CATTLE	10-Nov-12	A	NEG	A
	VIT 26/2012	CATTLE	10-Nov-12	A	NEG	A
	VIT 27/2012	CATTLE	10-Nov-12	O	NEG	O
	VIT 28/2012	CATTLE	10-Nov-12	NVD	NEG	NVD
	VIT 29/2012	CATTLE	10-Nov-12	NVD	NEG	NVD
	VIT 10/2013	CATTLE	11-May-13	NVD	POS	FMDV GD
	VIT 11/2013	CATTLE	21-May-13	O	POS	O
	VIT 12/2013	CATTLE	21-May-13	O	POS	O
	VIT 13/2013	CATTLE	21-May-13	O	POS	O
	VIT 14/2013	CATTLE	21-May-13	O	POS	O
	VIT 15/2013	CATTLE	31-May-13	O	POS	O
	VIT 16/2013	CATTLE	31-May-13	O	POS	O
	VIT 17/2013	CATTLE	20-Jun-13	NVD	POS	FMDV GD
	VIT 18/2013	CATTLE	20-Jun-13	O	POS	O
	VIT 19/2013	CATTLE	28-Jun-13	NVD	POS	FMDV GD
	VIT 20/2013	CATTLE	06-Aug-13	O	POS	O

	VIT 21/2013	CATTLE	06-Aug-13	NVD	POS	FMDV GD
	TOTAL:	**44**				

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 (July-September 2013)

Country	**No. of samples**	**Virus isolation in cell culture/ELISA**								**RT-PCR for FMD (or SVD) virus (where appropriate)**	
		FMD virus serotypes							**NVD**		
		O	**A**	**C**	**SAT 1**	**SAT 2**	**SAT 3**	**Asia 1**		**Positive**	**Negative**
KENYA	15	-	-	-	-	-	-	-	-	-	-
MONGOLIA	10	-	5	-	-	-	-	-	5	3	7
VIETNAM, SOCIALIST REPUBLIC OF	19	9	2	-	-	-	-	-	3	13	6
TOTAL	**44**	**9**	**7**	**-**	**-**	**-**	**-**	**-**	**8**	**16**	**13**

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 1st July to 30th September 2013.

Type O:

Vaccine Matching studies for serotype O FMDV by VNT						
SAMPLE REF	SEROTYPE	O Manisa	O TUR 5/09	O 3039	O 4625	O TAW/98
O/VIT/11/2013	O	M	M	M	NT	M
O/VIT/18/2013	O	M	M	M	NT	M
O/TAI/14/2012	O	N	N	borderline	NT	N
O/TAI/19/2012	O	M	M	M	NT	M
O/TAI/1/2013	O	N	borderline	M	NT	M
O/LAO/1/2012*	O	N	M	M	NT	M
O/LAO/5/2012*	O	N	M	M	NT	M
O/CAM/1/2012*	O	N	M	M	NT	M
O/CAM/2/2012*	O	N	M	M	NT	M
O/TUR/3/2013	O	borderline	M	M	NT	M
O/TUR/12/2013*	O	M	M	M	M	NT
O/TUR/24/2013*	O	borderline	M	N	M	NT
O/TUR/29/2013*	O	borderline	M	M	M	NT
O/BHU/1/2013	O	N	M	M	NT	M

* These seven isolates were also tested for matching against the O Russia vaccine and yielded results greater than 0.3 (matched).

Type A:

Vaccine Matching studies for serotype A FMDV by VNT					
SAMPLE REF	SEROTYPE	A Iran 2005	A22 Iraq	A May 97	A TUR 2006
A/MOG/1/2013	A	M	M	N	M
A/MOG/5/2013	A	M	M	N	M
A/TAI/13/2012	A	N	N	borderline	borderline
A/TAI/16/2012	A	N	N	N	N
A/TAI/2/2013	A	M	M	N	M
A/TAI/5/2013	A	N	N	M	N

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 (Pirbright Institute papers are highlighted in **BOLD**)

1: Gabalebatse M, Ngwenya BN, Teketay D, Kolawole OD. Ethno-veterinary practices amongst livestock farmers in ngamiland district, Botswana. Afr J Tradit Complement Altern Med. 2013 Apr 12;10(3):490-502. PubMed PMID: 24146479.

2: Geale DW, Barnett PV, Clarke GW, Davis J, Kasari TR. A Review of OIE Country Status Recovery Using Vaccinate-to-Live Versus Vaccinate-to-Die Foot-and-Mouth Disease Response Policies II: Waiting Periods After Emergency Vaccination in FMD Free Countries. Transbound Emerg Dis. 2013 Oct 17. doi: 0.1111/tbed.12165. [Epub ahead of print] PubMed PMID: 24131661.

3: Liang T, Yang D, Liu M, Sun C, Wang F, Wang J, Wang H, Song S, Zhou G, Yu L. Selection and characterization of an acid-resistant mutant of serotype O foot-and-mouth disease virus. Arch Virol. 2013 Oct 12. [Epub ahead of print] PubMed PMID: 24122111.

4: Namatovu A, Belsham GJ, Ayebazibwe C, Dhikusooka MT, Wekesa SN, Siegismund HR, Muwanika VB, Tjørnehøj K. Challenges for Serology-Based Characterization of Foot-and-Mouth Disease Outbreaks in Endemic Areas; Identification of Two Separate Lineages of Serotype O FMDV in Uganda in 2011. Transbound Emerg Dis. 2013 Oct 11. doi: 10.1111/tbed.12170. [Epub ahead of print] PubMed PMID: 24118785.

5: Barnett PV, Geale DW, Clarke G, Davis J, Kasari TR. A Review of OIE Country Status Recovery Using Vaccinate-to-Live Versus Vaccinate-to-Die Foot-and-Mouth Disease Response Policies I: Benefits of Higher Potency Vaccines and Associated NSP DIVA Test Systems in Post-Outbreak Surveillance. Transbound Emerg Dis. 2013 Sep 24. doi: 10.1111/tbed.12166. [Epub ahead of print] PubMed PMID: 24112127.

6: Flood JS, Porphyre T, Tildesley MJ, Woolhouse ME. The performance of approximations of farm contiguity compared to contiguity defined using detailed geographical information in two sample areas in Scotland: implications for foot-and-mouth disease modelling. BMC Vet Res. 2013 Oct 8;9(1):198. [Epub ahead of print] PubMed PMID: 24099627.

7: Halasa T, Willeberg P, Christiansen LE, Boklund A, Alkhamis M, Perez A, Enøe C. Decisions on control of foot-and-mouth disease informed using model predictions. Prev Vet Med. 2013 Sep 12. doi:pii: S0167-5877(13)00281-X. 10.1016/j.prevetmed.2013.09.003. [Epub ahead of print] PubMed PMID: 24080392.

8: Subramaniam S, Mohapatra JK, Sharma GK, Das B, Dash BB, Sanyal A, Pattnaik B. Phylogeny and genetic diversity of foot and mouth disease virus serotype Asia1 in India during 1964-2012. Vet Microbiol. 2013 Sep 6. doi:pii: S0378-1135(13)00437-9. 10.1016/j.vetmic.2013.08.023. [Epub ahead of print] PubMed PMID: 24060099.

9: El-Shehawy LI, Abu-Elnaga HI, Rizk SA, Abd El-Kreem AS, Mohamed AA, Fawzy HG. Molecular differentiation and phylogenetic analysis of the Egyptian foot-and-mouth disease virus SAT2. Arch Virol. 2013 Sep 18. [Epub ahead of print] PubMed PMID: 24046086.

10: Wright CF, Knowles NJ, Di Nardo A, Paton DJ, Haydon DT, King DP. Reconstructing the origin and transmission dynamics of the 1967-68 foot-and-mouth disease epidemic in the United Kingdom. Infect Genet Evol. 2013 Sep13;20C:230-238. doi: 10.1016/j.meegid.2013.09.009. [Epub ahead of print] PubMed PMID: 24035793.

11: Upadhyaya S, Ayelet G, Paul G, King DP, Paton DJ, Mahapatra M. Genetic basis of antigenic variation in foot-and-mouth disease serotype A viruses from the Middle East. Vaccine. 2013 Sep 10. doi:pii: S0264-410X(13)01214-0. 10.1016/j.vaccine.2013.08.102. [Epub ahead of print] PubMed PMID: 24035435.

12: Hayama Y, Yamamoto T, Kobayashi S, Muroga N, Tsutsui T. Mathematical model of the 2010 foot-and-mouth disease epidemic in Japan and evaluation of control measures. Prev Vet Med. 2013 Aug 30. doi:pii: S0167-5877(13)00275-4. 10.1016/j.prevetmed.2013.08.010. [Epub ahead of print] PubMed PMID: 24034814.

13: Valdazo-González B, Timina A, Scherbakov A, Abdul-Hamid NF, Knowles NJ, King DP. Multiple introductions of serotype O foot-and-mouth disease viruses into East Asia in 2010--2011. Vet Res. 2013 Sep 5;44(1):76. [Epub ahead of print] PubMed PMID: 24007643.

14: Mignaqui AC, Ruiz V, Perret S, St-Laurent G, Singh Chahal P, Transfiguracion J, Sammarruco A, Gnazzo V, Durocher Y, Wigdorovitz A. Transient gene expression in serum-free suspension-growing mammalian cells for the production of foot-and-mouth disease virus empty capsids. PLoS One. 2013 Aug 20;8(8):e72800. doi: 10.1371/journal.pone.0072800. PubMed PMID: 23977353; PubMed Central PMCID: PMC3748020.

15: Abd El Wahed A, El-Deeb A, El-Tholoth M, Abd El Kader H, Ahmed A, Hassan S, Hoffmann B, Haas B, Shalaby MA, Hufert FT, Weidmann M. A Portable Reverse Transcription Recombinase Polymerase Amplification Assay for Rapid Detection of Foot-and-Mouth Disease Virus. PLoS One. 2013 Aug 20;8(8):e71642. doi: 10.1371/journal.pone.0071642. PubMed PMID: 23977101; PubMed Central PMCID: PMC3748043.

16: Bhat SA, Saravanan P, Hosamani M, Basagoudanavar SH, Sreenivasa BP, Tamilselvan RP, Venkataramanan R. Novel immunogenic baculovirus expressed virus-like particles of foot-and-mouth disease (FMD) virus protect guinea pigs against challenge. Res Vet Sci. 2013 Aug 19. doi:pii: S0034-5288(13)00232-4. 10.1016/j.rvsc.2013.07.007. [Epub ahead of print] PubMed PMID: 23969204.

17: Chen TH, Lee F, Lin YL, Pan CH, Shih CN, Lee MC, Tsai HJ. Development of a Luminex assay for the detection of swine antibodies to non-structural proteins of foot-and-mouth disease virus. J Immunol Methods. 2013 Oct 31;396(1-2):87-95. doi: 10.1016/j.jim.2013.08.002. Epub 2013 Aug 17. PubMed PMID: 23962586.

18: Knight-Jones TJ, Rushton J. The economic impacts of foot and mouth disease - What are they, how big are they and where do they occur? Prev Vet Med. 2013 Aug 16. doi:pii: S0167-5877(13)00239-0. 10.1016/j.prevetmed.2013.07.013. [Epub ahead of print] PubMed PMID: 23958457.

19: Hajam IA, Dar PA, Chandrasekar S, Nanda RK, Kishore S, Bhanuprakash V, Ganesh K. Co-administration of flagellin augments immune responses to inactivated foot-and-mouth disease virus (FMDV) antigen. Res Vet Sci. 2013 Aug 12. doi:pii: S0034-5288(13)00246-4. 10.1016/j.rvsc.2013.07.021. [Epub ahead of print] PubMed PMID: 23941960.

20: Wong CL, Sieo CC, Tan WS. Display of the VP1 epitope of foot-and-mouth disease virus on bacteriophage T7 and its application in diagnosis. J Virol Methods. 2013 Nov;193(2):611-9. doi: 0.1016/j.jviromet.2013.07.053. Epub 2013 Aug 6. PubMed PMID: 23933075.

21: Wekesa SN, Muwanika VB, Siegismund HR, Sangula AK, Namatovu A, Dhikusooka MT, Tjørnehøj K, Balinda SN, Wadsworth J, Knowles NJ, Belsham GJ. Analysis of Recent Serotype O Foot-and-Mouth Disease Viruses from Livestock in Kenya: Evidence of Four Independently Evolving Lineages. Transbound Emerg Dis. 2013 Aug 12. doi: 10.1111/tbed.12152. [Epub ahead of print] PubMed PMID: 23931583.

22: Di Giacomo S, Brito BP, Perez AM, Bucafusco D, Pega J, Rodríguez L, Borca MV, Pérez-Filgueira M. Heterogeneity in the Antibody Response to Foot-and-Mouth Disease Primo-vaccinated Calves. Transbound Emerg Dis. 2013 Jul 30. doi: 10.1111/tbed.12130. [Epub ahead of print] PubMed PMID: 23895140.

23: Muroga N, Kobayashi S, Nishida T, Hayama Y, Kawano T, Yamamoto T, Tsutsui T. Risk factors for the transmission of foot-and-mouth disease during the 2010 outbreak in Japan: a case-control study. BMC Vet Res. 2013 Jul 24;9:150. doi: 10.1186/1746-6148-9-150. PubMed PMID: 23880398; PubMed Central PMCID: PMC3724691.

24: Borrego B, Rodríguez-Pulido M, Mateos F, de la Losa N, Sobrino F, Sáiz M. Delivery of synthetic RNA can enhance the immunogenicity of vaccines against foot-and-mouth disease virus (FMDV) in mice. Vaccine. 2013 Sep 13;31(40):4375-81. doi: 10.1016/j.vaccine.2013.07.008. Epub 2013 Jul 13. PubMed PMID: 23859841.

25: Sarangi LN, Mohapatra JK, Subramaniam S, Sanyal A, Pattnaik B. Antigenic site variation in foot-and-mouth disease virus serotype O grown under vaccinal serum antibodies in vitro. Virus Res. 2013 Sep;176(1-2):273-9. doi: 10.1016/j.virusres.2013.07.003. Epub 2013 Jul 12. PubMed PMID: 23850868.

26: Mahajan S, Mohapatra JK, Pandey LK, Sharma GK, Pattnaik B. Truncated recombinant non-structural protein 2C-based indirect ELISA for FMD sero-surveillance. J Virol Methods. 2013 Nov;193(2):405-14. doi: 10.1016/j.jviromet.2013.07.003. Epub 2013 Jul 10. PubMed PMID: 23850716.

27: Alexandrov T, Stefanov D, Kamenov P, Miteva A, Khomenko S, Sumption K, Meyer-Gerbaulet H, Depner K. Surveillance of foot-and-mouth disease (FMD) in susceptible wildlife and domestic ungulates in Southeast of

Bulgaria following a FMD case in wild boar. Vet Microbiol. 2013 Sep 27;166(1-2):84-90. doi: 10.1016/j.vetmic.2013.05.016. Epub 2013 Jun 14. PubMed PMID: 23830685.

28: Guo HC, Sun SQ, Jin Y, Yang SL, Wei YQ, Sun DH, Yin SH, Ma JW, Liu ZX, Guo JH, Luo JX, Yin H, Liu XT, Liu DX. Foot-and-mouth disease virus-like particles produced by a SUMO fusion protein system in Escherichia coli induce potent protective immune responses in guinea pigs, swine and cattle. Vet Res. 2013 Jul 4;44(1):48. doi: 10.1186/1297-9716-44-48. PubMed PMID: 23826638; PubMed Central PMCID: PMC3720265.

29: Hadorn D, Dürr S, Thür B, Schwermer H, Clemenz C, Bruckner L, Perler L, Jemmi T. [Does emergency vaccination make sense as a supporting element in control of foot-and-mouth disease in Switzerland]. Schweiz Arch Tierheilkd. 2013 Jul;155(7):399-404. doi: 10.1024/0036-7281/a000481. German. PubMed PMID: 23823744.

30: Boklund A, Halasa T, Christiansen LE, Enøe C. Comparing control strategies against foot-and-mouth disease: will vaccination be cost-effective in Denmark? Prev Vet Med. 2013 Sep 1;111(3-4):206-19. doi: 10.1016/j.prevetmed.2013.05.008. Epub 2013 Jun 20. PubMed PMID: 23791121.

31: Li X, Wang J, Liu J, Li Z, Wang Y, Xue Y, Li X, Cao H, Zheng SJ. Engagement of soluble resistance-related calcium binding protein (sorcin) with foot-and-mouth disease virus (FMDV) VP1 inhibits type I interferon response in cells. Vet Microbiol. 2013 Sep 27;166(1-2):35-46. doi: 10.1016/j.vetmic.2013.04.028. Epub 2013 May 21. PubMed PMID: 23764275.

32: Dar P, Kalaivanan R, Sied N, Mamo B, Kishore S, Suryanarayana VV, Kondabattula G. Montanide ISA™ 201 adjuvanted FMD vaccine induces improved immune responses and protection in cattle. Vaccine. 2013 Jul 18;31(33):3327-32. doi: 10.1016/j.vaccine.2013.05.078. Epub 2013 Jun 2. PubMed PMID: 23735678.

Annex 3. RECOMMENDATIONS FROM WRLFMD® ON FMD VIRUS STRAINS TO BE INCLUDED IN FMDV ANTIGEN BANKS – September 2013

High Priority

O Manisa
O PanAsia-2
O BFS or Campos
A24 Cruzeiro
Asia 1 Shamir
A Iran-05 (or A TUR 06)
A22 Iraq
SAT 2 Saudi Arabia *(or equivalent i.e. SAT 2 Eritrea)*

(not in order of importance)

Medium Priority

A Eritrea
SAT 2 Zimbabwe
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)*

(not in order of importance)

Low Priority

A Iran ’96
A Iran ’99
A Iran 87 or A Saudi Arabia 23/86 *(or equivalent)*
A15 Bangkok related strain
A87 Argentina related strain
C Noville
SAT 2 Kenya
SAT 1 Kenya
SAT 3 Zimbabwe