ANNUAL REPORT

2016-17

ICAR-DIRECTORATE OF FOOT AND MOUTH DISEASE
Mukteswar 263 138 (India)

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ICAR-Directorate of Foot and Mouth Disease
Mukteswar 263 138
Nainital, Uttarakhand, India

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Contents

1 Executive Summary

Globally, Foot-and-mouth Disease is the most important transboundary disease of economic importance. The economic losses to the livestock industry attributed to this dreaded disease are large. There are direct and indirect losses due to this menace. The causative FMD virus is antigenically diverse having seven distinct serotypes (O, A, C, Asia1 and Southern African Territories (SAT) 1-3) and multiple subtypes/genotypes in each serotype. Currently three serotypes (O, A and Asia1) are prevalent in India. Serotype O is the most prevalent one followed by serotypes Asia1 and A. A vaccination based FMD control programme was launched by Govt of India in 2004 in selected 54 districts with progressive expansion. Currently, this programme includes 460 districts of the country covering all the states of Southern peninsula (Kerala, Tamilnadu, Puducherry, Karnataka and Andhra Pradesh), Maharashtra, Goa, Daman and Diu, Gujarat, Punjab, Haryana, Delhi, Dadra and Nagar Haveli, Andaman & Nicobar Islands, Lakshadweep, Uttar Pradesh, Rajasthan, Bihar, Madhya Pradesh, Uttarakhand, West Bengal and Himachal Pradesh.

During the year 2016-17, a total 150 serotype confirmed FMD incidences were recorded in India. Maximum incidences were reported from the North eastern region, which is not covered under FMD-CP. In the southern peninsula, maximum incidences were recorded in the state of Karnataka. During the period, three states (Andhra Pradesh, Telengana and Tamilnadu) in southern region had no incidence of FMD. The entire southern peninsula has been covered under FMD-CP since 2010-11. The state of Punjab and Maharashtra also had no incidence of FMD during the period.

Table 2 Year wise break-up of incidences and FMDV serotypes involved during last five years

Year	Total	O	A	Asia1
2012-13	331	265	16	52
2013-14	472	454	08	10
2014-15	76	75	-	01
2015-16	252	244	06	02
2016-17	150	150	-	-

Serotype O was responsible for all the incidences recorded during the year. **For the first time, there was no incidence of both serotypes A and Asia1 in the country**

Vaccine matching exercise was carried out to evaluate antigenic relationship of field isolates with currently used vaccine strains to monitor antigenic variation, if any, occurring in the field, and to assess appropriateness of in-use vaccine strains. In case of serotype O, the vaccine strain INDR2/1975 covered 91% of the field isolates. This vaccine strain is able to provide optimal antigenic coverage over the circulating field strains. Phylogenetic analysis based on VP1 (1D) coding region was carried out to assess genetic variations, inter-strain relationships and track movement of the virus. During the year,

Table 1: Number of confirmed FMD incidences in different geographical regions of the country during the last five years.

Year	South	North	Central	West	East	North East	Total
2012-13	68	16	21	14	104	108	331
2013-14	228	32	35	27	103	40	472
2014-15	10	4	10	3	25	24	76
2015-16	89	18	26	23	44	52	252
2016-17	49	11	05	06	22	57	150

phylogenetic analysis of serotype O virus revealed extended and exclusive dominance of lineage 'Ind2001' strains.

Four seasons viz, winter (December to early April), summer (April to June), monsoon (June to September) and post monsoon (October to December) prevail in the country. It is generally accepted that high relative humidity (RH) and heavy rain during monsoon inhibit aerosol transmission of FMD virus. Usually incidences of FMD start occurring from August and peak in November and maintain until March. Maximum FMD incidences at the end of the monsoon and post monsoon season may be due to comparatively dry weather and moderate RH which is very much conducive for virus transmission. Incidences in summer months are less due to very high ambient temperature. This year maximum incidences of FMD were recorded during the months of January, February and March. Especially in the state of Karnataka, 30 of 47 incidences were recorded in January and February, and it appears to be extension from one incidence. In the month of May, the state of Assam recorded 9 incidences, which is unusual.

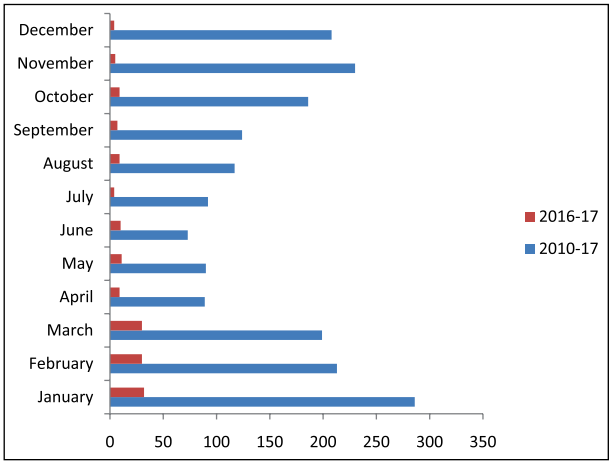


Fig 1: Monthly FMD incidences

National FMD Virus Repository was upgraded with new virus isolates. The virus repository has served the cause of the country by providing isolates for molecular epidemiological studies, evaluation of antigenic relatedness between the field and vaccine strains and selection of new candidate vaccine strains whenever required. A total of 57 virus isolates (53 serotype O and 4 serotype A) were added to the repository during the reported period. At present the National FMD virus Repository holds a total of 2065 isolates (O-1361, A-323, C-15 and Asia 1-366).

Under National FMD Serosurveillance, 61,297 bovine serum samples collected at random from various parts of the country were tested in r3AB3 NSP-ELISA (DIVA) for assessing the prevalence of NSP-antibody (NSP-Ab) positive animals, which is an indicator of FMD virus exposure regardless of vaccination status. The test revealed overall seropositivity in ~ 22.20% samples/animals, which is comparatively lesser than the previous year's average.

Four training programmes for the scientific staff of regional and collaborating centres were conducted on use/application of virus serotyping ELISA and DIVA ELISA. Overall performance of the regional and collaborating centres were monitored periodically and any technical difficulties faced by them were removed instantly through refresher courses and electronic guidance. Requirement of diagnostics kits in the country was met by the institute. Scientific staffs of the project were also undergone different training programme as part of human resource development. During the period, r3AB3 DIVA kit for FMD to test 94,380 samples and virus serotyping kits for 6000 tests was produced and supplied to the AICRP units.

During the year 2016-17, several new research projects for development were undertaken in the cutting-edge areas of FMDV research by the scientists of the institute. The potential of using FTA® cards for dry transportation of clinical samples and subsequent recovery of infectious FMDV by chemical transfection of FTA® card fixed RNA as an alternative to the conventional cell culture based virus isolation method was evaluated. A boiling-based RT-mPCR assay capable of detecting FMDV genome in tongue epithelial samples without the requirement for purifying RNA was developed as an alternative to the expensive and labour-intensive commercial RNA extraction kit. Using reverse genetics, FMDV serotype O IND R2/1975 displaying a FMDV serotype Asia1 B cell epitope at the capsid surface was constructed. The duration

of the FMD carrier state and associated serological responses subsequent to vaccination and naturally occurring infection at two farms in northern India was studied as a part of FMD ecology project. For the first time, FMDV associated abortion and vertical transmission following acute Infection in cattle under natural Conditions was reported. During the year, a collaborative (between ICAR-DFMD and IVRI) research project was under taken on vaccine development for FMD. The salient observations are mentioned subsequently in the report.

I am happy to share that ICAR-DFMD is a member of the Global FAO/OIE Network of FMD Reference Laboratories that constitutes of ten other FMD laboratories in the world. The institute also functions as the FAO-FMD Reference Center and SAARC Regional Leading Diagnostic Laboratory for FMD. The institute is also now a member of GFRA (Global FMD Research Alliance). The International Centre for FMD (ICFMD), a BSL3-Ag high containment facility was inaugurated on 01-04-2017 by Shri Radha Mohan Singh, Honourable Minister of Agriculture and Farmers Welfare, Govt. of India, Shri Dharmendra Pradhan, Honourable Minister of State (IC), Union Minister of Petroleum and Natural Gas, Govt. of India, Shri Pradeep Maharathy, Honourable Minister of Agriculture and Farmers Empowerment, Fisheries and Animal Resources Development, Govt. of Odisha, Dr. Trilochan Mohapatra, Secretary, DARE & Director General, ICAR, Shri Dilip Rath, Chairman, NDDB, Shri Sunil Kumar Singh, Additional Secretary and Financial Adviser, DARE/ICAR, Shri Chhabilendra Roul, Additional Secretary, DARE and Secretary, ICAR, Dr. H.Rahman, Deputy Director General (AS), ICAR and Dr. J.K Jena, Deputy Director General (Fy.), ICAR. The state-of-the-art research centre with high containment laboratory facility established by ICAR will cater to the need of researchers and scientists for safe handling of FMD virus as per international norms. The one-of-its-kind FMD research centre in South Asia, will help analyse exotic FMD virus strains in order to develop diagnostics and vaccines to prevent their incursion.

I thank all my fellow scientist colleagues, administrative, accounts and laboratory staff of the institute for their sincere efforts and contribution in accomplishing the tasks assigned to the Institute. We are indebted to the scientific and administrative support of Hon'ble Director General, ICAR, Secretary, ICAR and Dy Director General (AS), as well as Asst Director General (AH) and Principal Scientist (AH) for their support.

2

Vision, Mission, Mandate, Objectives and Technical Programme

Vision:

To make India free from Foot and Mouth Disease.

Mission:

Active epidemiological surveillance through regularly monitoring antigenicity and genomic make up of Foot and Mouth Disease virus strains responsible for disease incidences, to provide training in diagnosis and epidemiology, and to develop technologies for making country free from FMD.

Mandate:

Active epidemiological surveillance through regularly monitoring antigenicity and genomic make up of the FMD virus strains responsible for disease incidences, and also to provide training in diagnosis and epidemiology.

Objectives:

1. To conduct systematic epidemiological and molecular epidemiological studies on Foot-and- Mouth Disease (FMD), and also to study carrier status of the infection and latency of the virus.
2. Antigenic and molecular characterization and cataloguing of FMD virus strains isolated from incidences, and monitoring suitability of the vaccine strains in use along with maintenance of National Repository of FMD Virus.
3. Production, standardization and supply of diagnostic reagents for FMD virus serotyping and post-vaccinal sero-conversion. Maintenance and supply of most appropriate vaccine strain to the FMD vaccine manufacturers.
4. Development of newer diagnostic techniques using cutting-edge technologies in molecular biology.
5. Analysis of economic impact of FMD on livestock industry
6. To act as referral laboratory for FMD in South Asia.

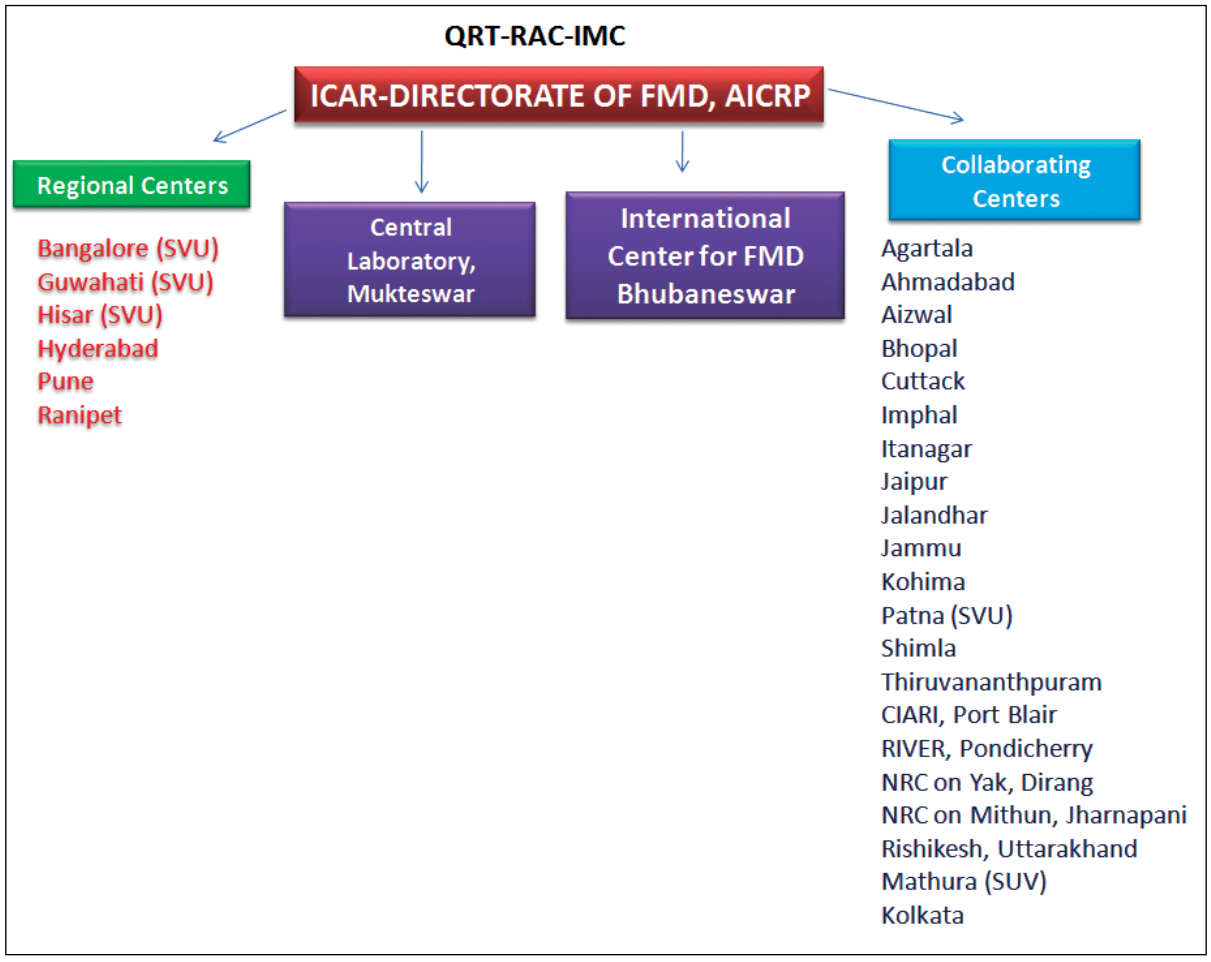
Technical Programme:

1. Active and passive surveillance of FMD in the country in AICRP mode
2. To carryout antigenic and molecular characterization of field isolates.
3. To study molecular epidemiology of FMD in India.
4. Confirmatory diagnosis and expert advice.
5. To carryout vaccine matching exercise for monitoring of appropriateness of in-use vaccine strains.
6. Maintenance of National Repository of FMD virus strains.
7. Production, standardization and supply of diagnostic kits for FMD virus diagnosis, sero-monitoring and serosurveillance.
8. To develop and standardize advanced laboratory techniques in compliance with the International standards and pass them on to the concerned Centres/Users/Stakeholders with proforma details to facilitate and ensure their uniform application.
9. To organize skill orientation programme for the scientific staff of the project for keeping them abreast with the latest knowledge and expertise from time to time through short-term training courses
10. Participation in FMD Control Programme with vital contribution in monitoring pre and post vaccinal antibody response for assessment of individual and herd immunity level.
11. National FMD Serosurveillance
12. International collaborations in areas of interest.

Organizational Setup

3

The ICAR-Directorate of Foot and Mouth Disease (FMD), the premier Institute for FMD in the country, was established as an All India Coordinated Research Project (AICRP) for FMD in 1968. During more than last four decades of its existence the scope of the project has been expanded progressively and several milestones were achieved. The AICRP was upgraded to the Project Directorate on FMD in July 2000 and Directorate of FMD since 2015-16 with 27 Regional and Collaborative covering all the major regions of the country. The Directorate has developed scientific expertise in conventional as well as in cutting edge areas, in the field of FMD diagnosis, epidemiology and research. The mandate of the institute is to carry out research on the epidemiology of FMD in the country and develop technologies to control the disease with ultimate goal of eradication. It is also entrusted with the duty of providing technical support and scientific input/ information to the planners and strategy making agencies in planning control of FMD in the country and the SAARC region.



Epidemiology Report

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Table 4.1 FMD cases/incidences recorded and diagnosed during 2016-17 and virus serotype(s) involved

States	Reporting AICRP Centre/Unit	No. of. FMD cases/ incidences	No. of. Samples tested	Virus Serotypes		
				O	A	Asia1
Southern Region						
Tamil Nadu	Ranipet	**No incidence**				
Andhra Pradesh	Hyderabad	**No incidence**				
Telengana	Hyderabad	**No incidence**				
Karnataka	Bangalore	42	93	42(67)	—	—
Kerala	Thiruvanthapuram	07	12	07(08)	—	—
Total		**49**	**105**	**49(75)**	—	—
Northern Region						
Haryana	Hisar	05	20	05(13)	—	—
Himachal Pradesh	Shimla	04	08	04(08)	—	—
Punjab	Jalandhar	**No incidence**				
Uttar Pradesh	Mathura/DFMD	01	05	01(01)	—	—
Uttarakhand	DFMD	01	05	01(03)	—	—
Total		**11**	**38**	**11(25)**	—	—
Central Region						
Madhya Pradesh	Bhopal	04	11	04(09)	—	—
Chhattisgarh	DFMD	01	36	01(33)	—	—
Total		**05**	**47**	**05(42)**	—	—
Western Region						
Gujarat	Ahmadabad	05	29	05(21)	—	—
Maharashtra	Pune	**No incidence**				
Rajasthan	Jaipur	01	04	01(01)	—	—
Total		**06**	**33**	**06(22)**	—	—
Eastern Region						
Odisha	Cuttack	07	**Samples could not be collected**			
Bihar	Patna	09	43	09(12)	—	—
West Bengal	Kolkata	13	45	13(28)	—	—
Total		**29**	**88**	**22(40)**	—	—

States	Reporting AICRP Centre/Unit	No. of. FMD cases/ incidences	No. of. Samples tested	Virus Serotypes		
				O	A	Asia1
North Eastern Region						
Assam	Guwahati	38	165	38(38)	—	—
Meghalaya		03	04	03(03)	—	—
Nagaland	Kohima	03	08	03(03)	—	—
Mizoram	Aizwal	02	04	02(04)	—	—
Manipur	Imphal	03	06	03(06)	—	—
Tripura	Agartala	02	03	02(02)	—	—
Arunachal	Itanagar	02	06	02(02)	—	—
Total		**57**	**212**	**57(58)**	—	—
Grand Total		**157**	**523**	**150(266)**	—	—

Number of samples collected from FMD suspected incidences and diagnosed is given in parenthesis. More than one clinical material was collected from many cases/incidences of FMD

4.1 Southern Region

Southern region comprises four states (Tamilnadu, Karnataka, Andhra Pradesh and Kerala) and has about 21% of the FMD susceptible livestock of the country. The region shares no international border and considered to be hyper endemic area for FMD especially the state of Karnataka. The entire southern peninsular region has been covered under FMD Control Programme (FMDCP) since the year 2010-11.

Tamilnadu: No incidence of FMD was reported during the period.

Andaman and Nicobar Island: No incidence of FMD was reported during the period.

Andhra Pradesh: No incidence of FMD was reported during the period.

Telengana: No incidence of FMD was reported during the period.

Karnataka: During the year, 42 FMD incidences were reported in the state. All of them were diagnosed to be serotype O (n=47). The incidences were widespread and reported from the districts of Bengaluru Urban (08), Bengaluru Rural (10), Chikballapura (06), Kolar (07), Tumkur (02), Ramnagara (03), Mandya (02), Gulbarga (02), Hassan (01) and Dakhsina Kanada (01).Majority of the incidences occurred in the month of January'17 (21) and February'17 (18), and all of them were epidemiologically linked, appear to be extension from a single incidence. Apart from incidences were recorded in the months of March'16 (02) and November'16 (01).

Kerala: A total of 7 FMD incidences were recorded in the state affecting only cattle. The incidences were caused by serotype O and were recorded in the districts of Alappuzha (03), Kozhikkode (01), Pathanamthitta (01), Thrissur (01) and Wayanad (01). The incidences were recorded in the months of April'16 (01), June'16 (03), July'16 (01), August'16 (01) and September'16 (01).

4.2 Central Region

Central region comprises two states (Madhya Pradesh and Chhattisgarh) and has about 10% of the FMD susceptible livestock of the country. The region shares no international border. The state of Madhya Pradesh has been covered under FMDCP since the year 2016-17.

Madhya Pradesh: During the period, four incidences of FMD were reported. The incidences occurred in the months of March'16 (02), September'16 (01) and October'16 (01) in the districts of Betul (02), Chhindwara (01) and Raisen (01). Species affected include cattle, buffalo and goat.

Chhattisgarh: One incidence of FMD due to serotype O was recorded in the state in the district of Raipur. The disease occurred in the month of August'2016 in cattle and buffalo

4.3 Western Region

Western region comprises three states (Maharashtra, Rajasthan and Gujarat) and has about 22% of the FMD susceptible livestock of the country. The region shares international border with Pakistan. All the three states in the western region have been covered under FMDCP since the year 2010-11.

Maharashtra: No incidence of FMD was reported during the period.

Gujarat: During the year, five FMD incidences were type confirmed and all of them were caused by serotype O. The incidences were recorded in the districts of Junagadh (01), Amreli (01), Botad (01) and Porbandar (01). The incidences, which were recorded in cattle and buffalo, occurred in the months of January (03), October (01) and December (01).

Rajasthan: One incidence of FMD due to serotype O was recorded in the state in the district of Sriganganagar

4.4 Northern Region

Northern region comprises six states (Haryana, Punjab, Jammu & Kashmir, Himachal Pradesh, Uttarakhand and Uttar Pradesh and has about 19% of the FMD susceptible livestock of the country. The region shares international border with Pakistan, Afghanistan, Nepal and China. The states of Haryana, Punjab, Uttarkhand, Himachal Pradesh and Uttar Pradesh are covered under FMDCP.

Punjab: No incidence of FMD was reported during the period.

Haryana: During the year, 5 incidences of FMD were recorded in the state and all of them were caused by serotype O. Two incidences were recorded in the month of March'16 and one incidence each in the months of April'16, January'17 and February'17. The incidences were reported from the districts of Hisar (03), Sirsa (01) and Kaithal (01). The species affected includes cattle, buffalo and pigs.

Himachal Pradesh: Four incidences/cases were recorded in the state due to FMDV serotype O. The incidences were recorded in the months of May (02), April (01 and January (01) in the districts of Kangra, Mandi and Hamipur. The disease occurred in cattle and buffalo.

Uttar Pradesh: One incidence of FMD due to serotype O was recorded in the state in the district of Meerut. The disease occurred in pig in the month of April'16.

Uttarakhand: One incidence of FMD due to serotype O was type confirmed in the state. The disease was reported from Udham Singh Nagar in the month of February'17

4.5 Eastern Region

Eastern region comprises four states (West Bengal, Odisha, Bihar and Jharkhand) and has about 22% of the FMD susceptible livestock of the country. The region shares international border with Bangladesh and Nepal. The states of Bihar and West Bengal are covered under FMDCP since 2015-16 and 2016-17, respectively.

Odisha: Seven incidences/cases were recorded in the state. The incidences occurred in bovine and ovine species. One incidence was diagnosed in retrospect. The incidences were reported in the districts of Puri (02), Khurda (01), Ganjam (01), Jagatsinghpur (01), Sundergarh (01) and Mayurbhanj (01). The incidences were recorded in the months of March (03), February (01), April (01), June (01) and August (01).

West Bengal: Thirteen FMD incidences/ cases of FMD owing to serotype O were recorded during the period in the state. Maximum incidences occurred in the month of March'16 (08) followed by October'16 (02), and one each in April'16, June'16 and January'17. Highest number of FMD incidences was in the district of Paschim Medinipur (07), two each in Hooghly and Nadia, and one each in Purba Medinipur and North 24 Paraganas. The disease occurred in cattle and goat.

Bihar: During the period under report, 9 incidences of FMD due to serotype O were recorded in the state. Maximum incidences were observed in the month of March'16 (07) and one each in the

months of October'16 and February'17. The disease was recorded in the districts of Patna (08) and Nalanda (01) in cattle and buffalo.

4. 6 North Eastern Region

North eastern region comprises seven states (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura) and has about 5% of the FMD susceptible livestock of the country. The region shares international border with China, Myanmar, Bangladesh and Bhutan. Currently not covered under FMDCP and vaccination for FMD is mainly carried through ASCAD scheme yearly once.

Meghalaya: Three incidences of FMD owing to serotype O were recorded in Cattle. All the incidences occurred in the district of Ri-Bhoi in the month of March'16 (01) and February'17 (02).

Nagaland: During the year, 7 incidences of FMD were recorded in the state and all of them were caused by serotype O. The incidences were reported in the districts of Kohima (03), Peren (02), Mokokchung (01) and Zunhuboto (01).The incidences were recorded in the months of March (02), January (02), February (01), April (01) and August (01). The disease occurred in cattle and buffalo.

Arunachal Pradesh: During the year, 2 incidences of FMD were recorded in the state and were caused by serotype O. The incidences were recorded in the month of October'16, one each in District of Papumpara and Namsai. The incidence in Papumpara was recorded in Mithun and Cattle were involved in Namsai.

Assam: Forty one incidences of FMD were recorded in the state during the period. Serotype O accounted for all the incidences that were recorded in cattle, buffalo, goat and pig. The incidences were recorded throughout the year in the months of March (01), April (01), May (09), June (05), July (03), August (05), September (02), October (02), November (04), December (01), January (04) and February (04). The disease was widespread and occurred in the districts of Barpeta (04), Kamrup (05), Dhemaji (05), North Lakhimpur (02), Bongaigaon (02), Sivasagar (01), Golaghat (02), Sonitpur (03), Darrang (05), Goalapara (02), Nagaon (02), Dighalbari (01), Majuli (01), Golaghat (01), Khanapara (01) and Zunhuboto (01)

Manipur: During the year, 3 incidences/cases of FMD due to serotype O were reported in cattle. One incidence each was recorded in the districts of Thoubal, Chandel and Bishnupur in the months of September'16 (02) and December'16 (01).

Mizoram: Two incidences/cases were recorded in the state due to FMDV serotype O. The incidences were recorded in the months of April'16 and May'16 in the districts of Aizawl and Lawngtlai, respectively affecting only cattle.

Tripura: During the period under report, 2 incidences of FMD due to serotype O were recorded in the state. One incidence in the district of Tripura West was recorded in the month of December'16. Another incidence was reported form Khowai district in the month of February'17. The diseases were recorded only in cattle.

Molecular Epidemiology of FMD Virus Field Isolates

5

5.1 FMDV serotype O

During 2016-17, a total of 44 serotype O field isolates were subjected to complete 1D/VP1 region sequence analysis. Maximum Likelihood (ML) tree was reconstructed using MEGA 6.06 software package. In the ML tree all the 44 isolates grouped within O/ME-SA/Ind2001 lineage indicating its dominance in the field (Fig.5.1). The lineage, which re-emerged in the year 2008, continued its supremacy in the field by displacing the then prevalent O/ME-SA/PanAsia lineage. Since its actual identification in the year 1997, the lineage has diversified globally in to at least four sub-lineages (Ind2001a, b, c and d). The majority (n=39) of the isolates of O/ME-SA/Ind2001 lineage currently circulating in the country grouped distantly from sub-lineage Ind2001d that caused several FMD incidences during the year 2013 in the southern region. This sub-cluster designated here as sub-lineage Ind2001e had a mean nucleotide divergence of 7.4% from the Ind2001d isolates. Furthermore, five isolates collected from the states of Uttarakhand and Uttar Pradesh clustered with Ind2001d sub-lineage indicating its extended circulation. The Ind2001e sub-lineage was found distributed in the states of Chhattisgarh, Karnataka, Uttar Pradesh and Tamilnadu. Isolates collected from Uttar Pradesh were clustered in both Ind2001d and Ind2001de sub-lineages indicating multiple independent incursion of virus in to the state. The Ind2001 isolates collected during 2016 differed from currently used vaccine strain INDR2/1975 by 12.1 to 14.2% at nucleotide level at 1D genomic region nucleotide sequence.

Capsid region (P1) diversity in serotype O virus strains

The capsid coding region of 24 serotype O isolates were compared. A perfect conservation at antigenic sites was observed except for changes at four sites in a few isolates. In one isolates Leucine-Serine variation was observed at antigenic site 1 (residue VP1-148). At antigenic site 3, four isolates revealed Lysine-Asparagine substitution at position 45 of VP1. Two substitutions were observed at antigenic site 2 at position VP2-71 and VP2-131 in one isolate each. Out of these 7 isolates, deviation in antigenic value was observed only in two isolates. It has to be noted that correlating antigenic diversity with that of amino acid sequence changes is not well established. There may be some other factors; unidentified antigenic site, in-vivo phenomenon etc may have a role in antigenic variability.

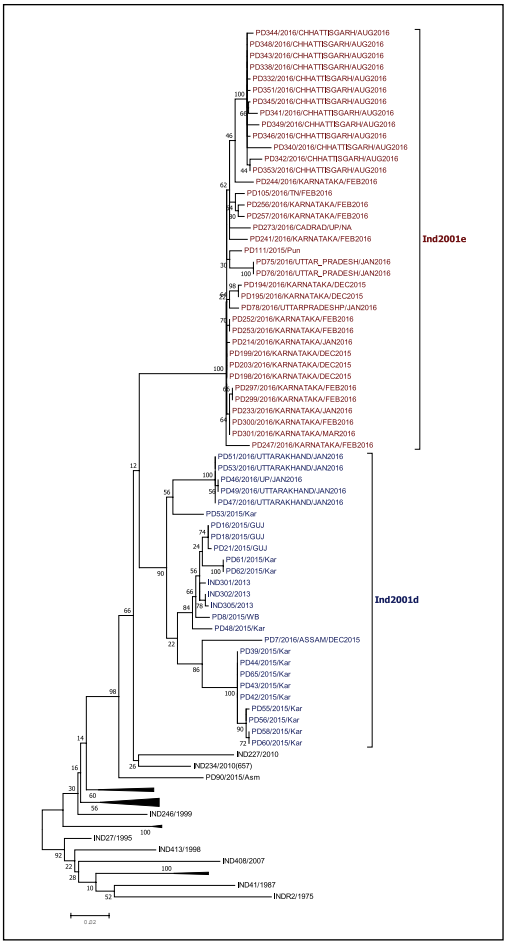


Fig. 5.1 Maximum Likelihood phylogenetic tree at VP1(1D) coding region of Indian serotype O FMD virus isolates during 2015-16. The tree shows complete dominance O/ME-SA/Ind2001e sub-lineage in India during the period. The lineage Ind2001 has been predominantly circulating in the country since the year 2008.

6 Vaccine Matching of FMD Virus Field Isolates/Strains

6.1 FMDV serotype O

The antigenic relationships of serotype O field isolates with the currently used vaccine strain INDR2/1975 is shown in Fig.6.1. The test results were interpreted as per criteria set by Rweyemamu, (1984). A total of 46 isolates were subjected to vaccine matching exercise using bovine vaccinate serum during 2016-17. From the result, it was observed that 91% of the isolates showed an r1 value of >0.3 (antigenic similarity/relatedness) with currently used vaccine strain INDR2/1975 and 9% had an r1 value of <0.3. Emergence of antigenic variant in an endemic country is a normal phenomenon and the currently used vaccine strain INDR2/1975 still is able to provide near optimal antigenic coverage to the field isolates. Further, four candidate vaccine strains (IND408/2007 and IND320/2007 (PanAsia II), IND271/2001 (PanAsia) and IND120/2002 (Ind2001) representing different lineages are being evaluated with field isolates to find better strain for use in case any emergency/requirement.

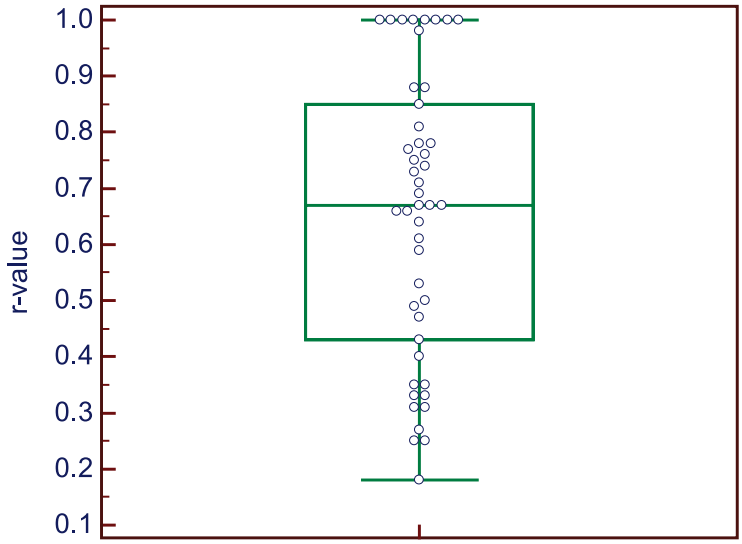


Fig. 6.1 r_1- values of FMD virus serotype O isolates collected during 2016 with currently used vaccine strain INDR2/1975

Researches for Development

7

7.1 FMD Diagnosis

Application of Absorbent cards followed by RNA transfection

Inadequate storage and shipment of suspected clinical samples can compromise the ability to detect and characterise FMDV in endemic countries, thereby, leading to the loss of valuable virological and epidemiological data. This study, investigated the potential of using FTA® cards (an absorbent cards) for dry transportation of clinical samples and subsequent recovery of infectious FMDV by chemical transfection of FTA® card fixed RNA as an alternative to the conventional cell culture based virus isolation method. A higher proportion of infectious FMDV was rescued from clinical samples (cell culture isolates, tongue epithelial suspension and impression smears) collected on FTA® card and subsequent RNA transfection in BHK-21 cells (76%) compared to the conventional cell culture based virus isolation method (56%), suggesting a better performance of the current RNA transfection procedure for rescue of infectious virus in cell culture. Furthermore, it was possible to rescue live virus by the transfection of RNA extracted from FTA® card impregnated with clinical samples that had been stored at varying temperature (4–37 °C) up to a period of six weeks. The VP1(1D) sequence data and antigenic relationships with the vaccine strains, between viruses rescued by FTA® card fixed RNA transfection and conventional cell culture, were comparable. Therefore, these results support the use of appropriate absorbent card for the economic, dry, non-hazardous transport of FMD suspected clinical samples from the site of collection to national/ international reference laboratories.

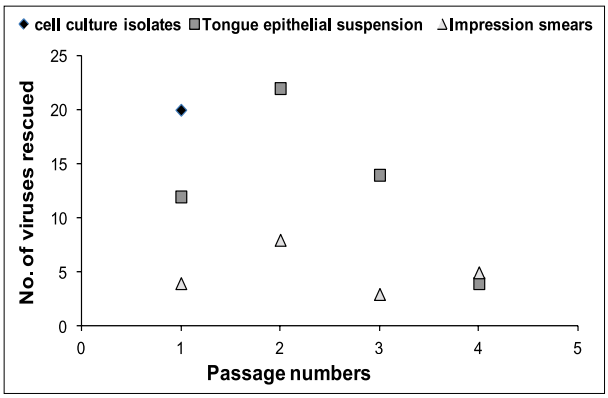


Fig 7.1.1 Number of infectious FMDV rescued by chemical transfection of RNA extracted from FTA card fixed clinical samples at different passage levels.

Direct boil RT-mPCR

Simple, rapid and economical diagnosis of FMDV plays a critical role in the implementation of suitable measures to control the spread of the disease. A boiling-based RT-mPCR assay capable detecting FMDV genome in tongue epithelial samples without RNA purification was developed as an alternative to the expensive and labour-intensive commercial RNA extraction kit. The direct boil RT-mPCR assay allowed far easier, faster and cost-effective detection of FMDV genome compared to the RNA extraction-based assay without affecting the specificity and sensitivity. However, the boiling method may not be applicable for detection of FMDV genome in infected blood and milk samples. Simple boiling of samples without additional purification steps can be used as an alternative RNA preparation method to detect FMDV genome in cell culture and tongue epithelial suspensions.

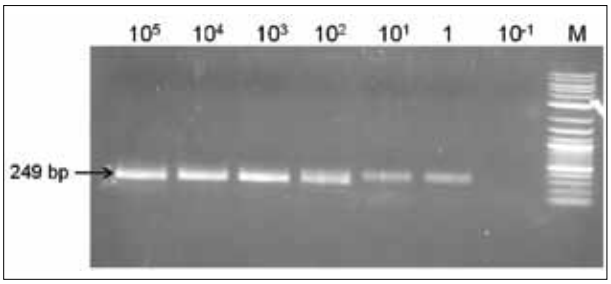


Fig 7.1.2 Detection limits of direct-boil RT-mPCR on serotypes O. Numerical at the top indicates infectious titer (TCID50/ml) of the virus dilutions used for RNA extraction. The arrow indicates the 249bp target amplicon (VP1 region) of FMDV serotype O. MW: molecular weight marker (100 bp ladder, Fermentas).

Detection of FMDV in cow milk

Nucleic acid recognition methods (mPCR and RT LAMP) were applied successfully to detect FMD virus in milk during and after the subset of FMD incidence. Analytical sensitivity of these methods was estimated using uninfected negative milk sample spiked with $10^{5.7}$ TCID50/ml FMD serotype O virus (IND R2/1975) in 10 fold serial dilution. Detection limit of mPCR and RTLAMP assay was $10^{2.7}$ and $10^{1.7}$ TCID50/ml, respectively. Virus isolation from individual and pooled milk from infected cow was positive till 6 and 4 days post clinical manifestation (dpm), respectively. Individual milk and pooled milk samples were found positive by m-PCR till 37 and 14 dpm, respectively, but by RT-LAMP till 37 and 21 dpm, respectively. mPCR and RT LAMP assays has potential to detect FMD virus in milk and help to prevent the spread of FMD virus from one place to another place via milk and its transport.

7.2 FMD Vaccine development

Chimeric FMDV serotype O displaying a serotype Asia1 antigenic epitope

Using reverse genetics, FMDV serotype O IND R2/1975 displaying a FMDV serotype Asia1 B cell epitope at the capsid surface was constructed. The epitope-inserted recombinant chimeric virus was genetically stable up to ten serial passages in cell culture and exhibited growth properties similar to the parental serotype O virus. Furthermore, the surface-displayed Asia1 epitope able to react with serotype Asia1 specific antibodies in a competitive ELISA. Importantly, the recombinant chimeric virus showed neutralizing activity to both serotype O and Asia1 polyclonal antibodies, making this an attractive approach for the design of new generation bi-valent FMD vaccines.

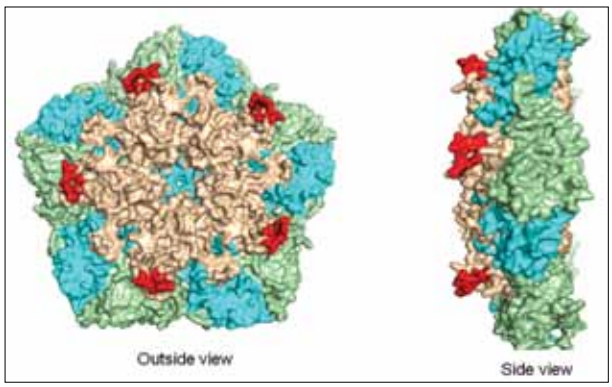


Fig 7.2.1 Location of the inserted Asia1 epitope (red) on the capsid surface of the recombinant chimeric FMD virus (vOR2/1975-Asia1-Epi). Outside view (a) and side view (b) of a pentameric subunit in the capsid. VP1 is wheat coloured, VP2 is green and VP3 is cyan coloured.

7.3 FMDV Pathogenesis

Quantitative characteristics of the FMD carrier state under natural conditions in India

The duration of the FMD carrier state and associated serological responses subsequent to vaccination and naturally occurring infection at two farms in northern India was studied. Despite previous vaccination of cattle in these herds, clinical signs of FMD occurred in October 2013 within a subset of animals at the farms containing juvenile-yearling heifers and steers (Farm A) and adult dairy cattle (Farm B). Subsequent to the incidence, FMDV asymptomatic carriers were identified in both herds by seroreactivity to FMDV non-structural proteins and detection of FMDV genomic RNA in oropharyngeal fluid. Carriers' seroreactivity and FMDV genome detection status were subsequently monitored monthly for 23 months. The mean extinction time of the carrier state was 13.1 ± 0.2 months, with extinction having occurred significantly faster amongst adult dairy cattle at Farm B compared to younger animals at Farm A. The rate of decrease in the proportion of carrier animals was calculated to be 0.07 per month. Seroprevalence against FMDV non-structural proteins decreased over the course of the study period, but was found to increase transiently following repeated vaccinations. These data provide novel insights into viral and host factors associated with the FMDV carrier state under natural conditions.

FMDV associated abortion and vertical transmission in cattle

During some FMD incidences in India, spontaneous abortions were reported amongst clinically affected and asymptomatic cows. The current study was an opportunistic investigation

of these naturally occurring bovine abortions to identify cause of abortion and possibility of vertical transmission of FMDV from infected cow to fetus. For this purpose, fetal tissue samples of eight abortuses (heart, liver, kidney, spleen, palatine tonsil, umbilical cord, soft palate, tongue, lungs, and submandibular lymph node) were collected and screened by various detection methods, including viral genome detection, virus isolation, and immunomicroscopy. Amongst these cases, gross pathological changes were observed in 3 abortuses. Gross pathological findings included blood-tinged peritoneal and pleural effusions and myocarditis. Hearts of infected fetus had mild to moderate degeneration and necrosis of the myocardium with moderate infiltration by mixed inflammatory cells. FMDV antigen was detected in lungs and soft palate by immunomicroscopy. FMDV serotype O viral genome was recovered from 7 of 8 fetus. Infectious FMDV serotype O was rescued by chemical transfection of the total RNA extracted from three soft palate samples and was sequenced to confirm 100% identity of the VP1 (capsid) coding region with isolates collected from infected cattle during the acute phase of infection. Based upon these findings, it is concluded that FMDV-associated abortion occurred among the infected pregnant cows investigated in this study, and FMDV was transmitted vertically to foetuses causing abortion and histo-immunopathological changes. This is the first documentation of FMDV-associated abortions in cattle.

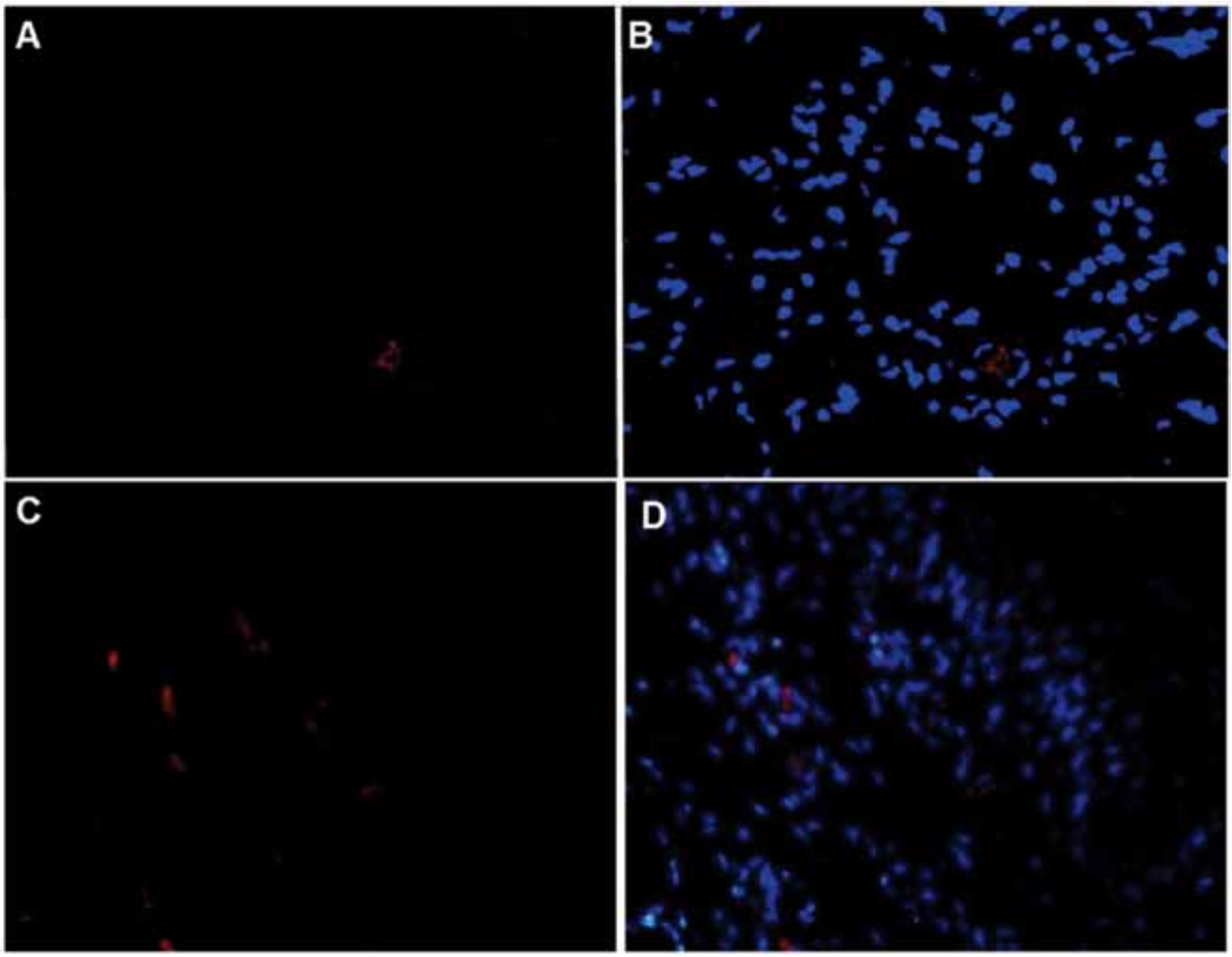
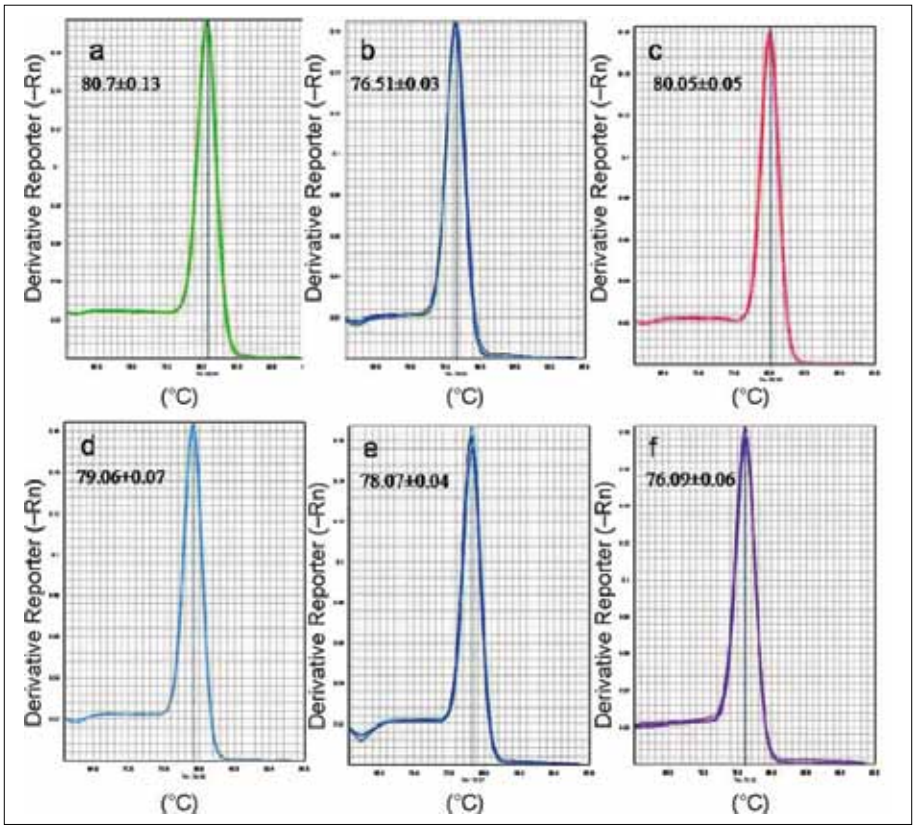


Fig 7.3.1. FMDV antigen detection by multi-channel immunofluorescence technique. **(A)** FMDV antigen (red) in few cells in lungs of aborted fetus from Dam ID#454 by indirect fluorescence assay (IFA). **(B)** Same image as shown in panel (A) merged with nuclear staining by DAPI (blue). **(C)** FMDV antigen (red) subjacent to basal epithelial cells in dorsal soft palate of aborted fetus. **(D)** Same image shown in panel (C) merged with nuclear staining by DAPI (blue). Rabbit anti-FMDV serotype O and rodamine-conjugated goat anti-rabbit. 40x magnification (doi:10.1371/journal.pone.0167163.g003)

Bovine toll like receptors (TLRs) in FMD vaccinated cattle

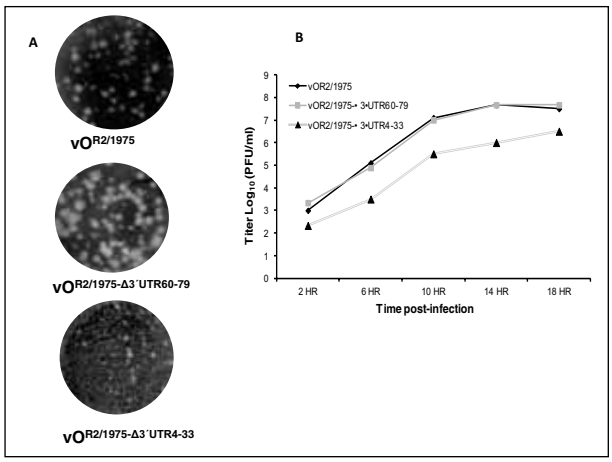
FMDV elicits acute humoral antibody response in both infected and vaccinated animals. Toll like receptors (TLRs) are type 1 transmembrane proteins expressed in almost all cell types and activate the innate immune system. The current study was performed to evaluate expression profiling of bovine TLRs viz; TLR 2, TLR 3, TLR 7, TLR 8 and TLR 10, in response to FMD inactivated vaccine using quantitative real-time RT-PCR technique. Blood samples were collected from control, test group 1 and test group 2, at 0, 14th and 21st days post-vaccination (dpv). The mRNA abundance of these target genes was calibrated with a housekeeping gene (18 S RNA) and expressed as fold over expression of the TLRs genes in bovine over the 0th dpv as control. On 0 day, expression of all TLRs did not vary significantly. The expression of TLR2 and TLR3 genes significantly increased in both test group 1 and 2 after 14th day and 21st dpv but expression of other TLRs in test groups 1 and 2 did not differ significantly. Expression of TLR2 and TLR3 genes considerably increased in test group 1 and 2 but expression of these genes was more in test group 1 as compared to test group 2. It indicates possible inclusion of TLR2 and TLR 3 agonist in vaccine to enhance the innate immunity of animals and help in clearance of virus.



Genomic region dispensable for virus replication.

The 3' untranslated region (3' UTR) of the foot-and-mouth disease virus (FMDV) genome plays an essential role in virus replication, but the properties of the 3' UTR are not completely defined. In order to determine the role of different regions of the 3' UTR in FMDV replication, site-directed mutagenesis of the 3' UTR of FMDV serotype O IND R2/1975 using a cDNA clone was conducted. Through independent serial deletions in various regions of the 3' UTR, we demonstrated that deletion of nucleotides between the stem-loop (SL) structures and in the beginning and the end regions of the SL2 structure could be lethal for FMDV replication. However, a block deletion of 20 nucleotides (nt 60 to 79) in the middle of SL2 did not affect the viability of FMDV in cultured cells. Characterisation of the deletion mutant virus ($O^{R2/1975}$-D30UTR 60–79) revealed no significant difference in growth kinetics

or RNA replication ability compared to the parental virus. However, the mutant virus produced slightly larger plaques when compared to the parental virus. This is the first description of a dispensable 20-nucleotide region in SL2 of the FMDV 3' UTR.



7.4 FMDV surveillance

FMD in small ruminant

Small ruminants (sheep and goats) are susceptible to FMDV, while studies with due emphasis on their role in the disease epidemiology have been meagre. The results of clinico-molecular investigation of FMD in sheep and goats across several states of India during 2008–2014 was summarized, where a total of 51 clinical epithelial tissue samples (vesicle/tongue/gum/foot epithelium) from sheep and 78 from goats were found positive for FMD virus (FMDV) serotype O in serotyping ELISA and multiplex reverse transcription-PCR. The VP1 region-based phylogenetic analysis demonstrated the involvement of O/ME-SA/Ind2001 lineage of serotype O virus in the incidences. The field viruses recovered from both small and large ruminant population during the same time period showed a close genetic relationship suggesting frequent inter-species transmission of virus. Since the disease often remains clinically camouflaged in small ruminants, the animals silently infected with FMD may pose potential threat to the in-contact livestock. Regular vaccination combined with surveillance and monitoring of protective antibody status in these species is therefore crucial to the effective control of FMD.

Foot-and-mouth disease in wildlife

A total of 41 clinical samples (vesicle/tongue/foot/nasal epithelium) from Indian gaur, deer, spotted deer, nilgai, chowsinga, bison, black buck, elephant, sambar deer were collected in 50% phosphate buffered saline/glycerol medium (pH-7.5) during suspected FMD incidences. Supernatants of homogenized clinical samples were used in a serotype differentiating antigen detection ELISA, and samples found negative were further subjected to multiplex PCR (mPCR). A total of 3/11 (27.2%) samples from Indian gaur, 2/7 (28.5%) chital deer, 5/5 (100%) nilgai, 2/2 (100%) black buck were found positive for serotype O in antigen detection ELISA. A total of 3 ELISA-negative samples from spotted deer, 2 from bison and 2 from sambar deer were found positive for serotype O in mPCR. The VP1 region-based phylogenetic analysis indicated the involvement of both O/ME-SA/Ind2001 and PanAsia lineage of serotype O in the incidences. The wildlife species has threat from domesticated animals, human beings and other materials being brought in.

National FMD Virus Repository

8

The Central FMD laboratory of the Project Directorate maintains the National FMD Virus Repository that is upgraded annually with addition of latest/new virus isolates. The virus repository has served the cause of the country by providing isolates for molecular epidemiological studies, evaluation of antigenic relatedness between the field and vaccine strains and selection of new candidate vaccine strains whenever required. A total of 57 virus isolates (53 serotype O and 4 serotype A) were added to the repository during the reported period (Table 8.1). At present the National FMD virus Repository holds a total of 2065 isolates (O-1361, A-323, C-15 and Asia 1-366).

Table 8.1. Year-wise details of the virus isolates added to National FMD Virus Repository during last six years

Isolates revived	O	A	Asia1	Total
2011-12	46	03	13	62
2012-13	32	19	26	77
2013-14	61	10	2	73
2014-15	12	-	4	16
2015-16	55	11	2	68
2016-17	53	4	-	57

Fig 8.2 State-wise distribution of FMD virus isolates (n=2065) available in National FMD virus repository as on Feb 2017

State-wise distribution of FMD virus Serotype O isolates (n=1361) available in National FMD virus repository as on Feb 2017

State-wise distribution of FMD virus serotype Asia1 isolates (n=366) available in National FMD virus repository as on Feb 2017

State-wise distribution of FMD virus serotype A isolates (n=323) available in national FMD virus repository as on Feb 2017

State-wise distribution of FMD virus serotype C isolates (n=15) available in National FMD virus repository as on Feb 2017

National FMD Serosurveillence

9

9.1 Differentiation of infected from vaccinated animals (DIVA)

Seroconversion against non structural protein is observed since 10-14 days after FMD virus infection. Whereas, if the animal is not exposed to FMD virus infection but vaccinated with inactivated purified polyvalent FMD vaccine, no anti-NSP immune response is elicited in host's body. This differential induction of anti-NSP antibody is exploited in DIVA ELISA to discriminate between infected and vaccinated animals. In this DIVA test reactivity of anti-3AB3 antibodies present in the serum of an infected animal (bovine species only) was assessed using purified recombinant 3AB3 (~38 kD) NSP in an indirect ELISA. The test is considered to be valid provided the mean absorbance of the positive control wells is not less than 0.8. Likewise a plate has to be rejected if the mean absorbance of the negative control serum is > 0.3. The O.D. in back ground control wells should also be less than 0.1. To reduce inter-run variation due to differences in absolute absorbance between runs/tests, final results for each test serum is expressed as the PP value [(test serum sample mean OD/positive control serum mean OD) x 100] i.e., percent positivity value or PP value. The results are interpreted based on the following cut-off zones:

1. 3AB3 NSP reactivity positive: If PP value is more than 40%
2. 3AB3 NSP reactivity negative: If PP value is less than 40%

During the year, a total of 61,297 bovine serum samples collected at random from various parts of the country were tested in r3AB3 NSP-ELISA for assessing NSP-antibody (NSP-Ab) response, which is an underlying indicator of FMD virus exposure regardless of vaccination status. The test revealed overall seropositivity (DIVA positive) in ~ 22% samples/animals (Table 9.1.1). The test also included serum samples from recent suspected incidence areas

Table 9.1.1 Result summary of r3AB3 NSP-ELISA on bovine (cattle and buffalo) serum samples (Regional and Collaborating centers and Central FMD lab)

Sl. No.	Place of origin	Host	Total serum samples tested	Total positive	%3AB3 reactors
Southern Region					
1	Telangana	Bovine	1800	162	9.0
2	Andhra Pradesh	Bovine	2600	586	22.5
3	Karnataka	Bovine	5973	1839	30.8
4	Tamil Nadu	Bovine	6000	1664	27.7
5	Kerala	Bovine	2520	442	17.5
Central Region					
5	Madhya Pradesh	Bovine	9484	1924	20.3
Western Region					
7	Rajasthan	Bovine	2340	836	35.73
8	Gujarat	Bovine	2800	584	20.86

Sl. No.	Place of origin	Host	Total serum samples tested	Total positive	%3AB3 reactors
9	Maharashtra	Bovine	4467	1156	25.88
Eastern Region					
10	West Bengal	Bovine	2492	839	33.7
12	Odisha	Bovine	1721	578	33.6
Northern Region					
13	Haryana	Bovine	217	125	57.6
14	Uttarakhand	Bovine	599	84	14.0
15	Uttar Pradesh	Bovine	9040	1427	15.8
16	Himachal Pradesh	Bovine	1598	131	8.2
18	Punjab	Bovine	2021	200	9.9
North Eastern Region					
19	Assam	Bovine	870	323	37.1
22	Manipur	Bovine	1800	227	12.6
23	Mizoram	Bovine	760	108	14.2
24	Tripura	Bovine	900	28	3.1
Islands					
25	Andaman and Nicobar	Bovine	939	8	0.9
Total		Bovine			
	NRC on Yak	Yak	356	261	73.6
	TOTAL		61,297	13532	22.0

Table 9.1.2. Summary of r3AB3 NSP-ELISA During 2008-09 to 2016-17; the prevalence has been around 25%

Year	Total samples tested	Total positive	% DIVA reactors
2008-09	18,326	5,120	27.94
2009-10	29,763	8,303	27.90
2010-11	31,042	8,341	26.87
2011-12	37,467	10,410	26.09
2012-13	40,934	10,811	26.41
2013-14	52,224	15,268	29.20
2014-15	68,948	16,139	23.41
2015-16	62,605	14112	22.54
2016-17	61,297	13532	22.0
Total	4,02,606	1,01,922	25.32

9.2 Post Vaccination seromonitoring

During the year under report, a total of 7867 serum samples were subjected to SP- ELISA for determination of antibody level against structural protein (SPs) of serotypes O, A and Asia1.

Table 9.2.1. FMD SP antibody status on random serum samples.

Gujarat	Bovine	676	611 (90.4)	582 (86.1)	638 (94.4)
Rajasthan	Bovine	181	166 (91.7)	178 (98.3)	176 (97.2)
Haryana	Bovine	158	152 (96.2)	141 (89.2)	147 (93.0)
Uttarakhand	Bovine	485	191 (39.4)	123 (25.4)	142 (29.3)
Punjab	Bovine	2000	1334 (66.7)	1250 (62.5)	1282 (64.1)
Himachal Pradesh	Bovine	200	155 (77.5)	165 (82.5)	163 (81.5)
West Bengal	Bovine	2496	1304 (52.2)	1239 (49.6)	1309 (52.4)
Assam	Bovine	1018	307 (30.2)	174 (17.0)	119 (11.2)
Mizoram	Bovine	461	331 (71.8)	301 (65.3)	358 (77.7)
Andaman & Nicobar	Bovine	192	113 (58.9)	130 (67.7)	131 (68.2)
Total		**7867**	**4664 (59.3)**	**4283 (54.4)**	**4465 (56.8)**

Percentage serum samples having protective titre against serotypes O, A and Asia 1 is given in parenthesis

Post Vaccinal Seroconversion Studies

10

10.1 Sero-monitoring of FMD Control Programme (FMD-CP)

A vaccination based FMD Control Programme (FMD-CP) has been initiated by the Government of India since 2004 covering 54 specified districts (Phase I) in the country. This involves 6 monthly vaccinations with a trivalent O, A and Asia1 vaccine of all cattle and buffaloes against FMD. Serum samples before vaccination and 21 to 30 days post vaccination are collected by the respective state AH department and submitted to testing centers of ICAR-DFMD for estimation of level of serotype specific antibodies by Liquid Phase Blocking ELISA. The Regional and Collaborative Centers, and Central FMD laboratory of the Directorate participate in this post vaccinal sero-conversion under FMD-CP. Due to initial success, additional 167 districts (another 80-90 million cattle and buffalo) have been included under the programme in 2010-11 (Phase II), and 110 districts have been included since 2013-14 (Phase III), and 38 districts in 2015-16 (Phase IV). The states of West Bengal, Himachal Pradesh, Madhya Pradesh and Uttarakhand have been covered since 2017 (Phase V). Currently, this programme includes 460 districts of the country covering all the states of Southern peninsula (Kerala, Tamilnadu, Puducherry, Karnataka and Andhra Pradesh), Maharashtra, Goa, Daman and Diu, Gujarat, Punjab, Haryana, Delhi, Dadra and Nagar Haveli, Andaman & Nicobar Islands, Lakshadweep, Uttar Pradesh, Rajasthan, Bihar, Madhya Pradesh, Uttarakhand and Himachal Pradesh. During the year, no LPB ELISA kit was supplied to the FMD CP seromonitoring testing centres due to police/legal complications.

Fig 10.1 Phase of FMD-CP. Phase I: 54 districts were covered since the year 2004 (filled Red). Phase II: 167 districts were covered since the year 2011(filled Green).Phase III: 110 districts were covered since the year 2014 (filled Yellow). Phase IV: 38 districts were covered since the year 2016 (filled Blue). Phase V: 91 districts were covered since the year 2017 (filled Pink).

Andaman & Nicobar Island

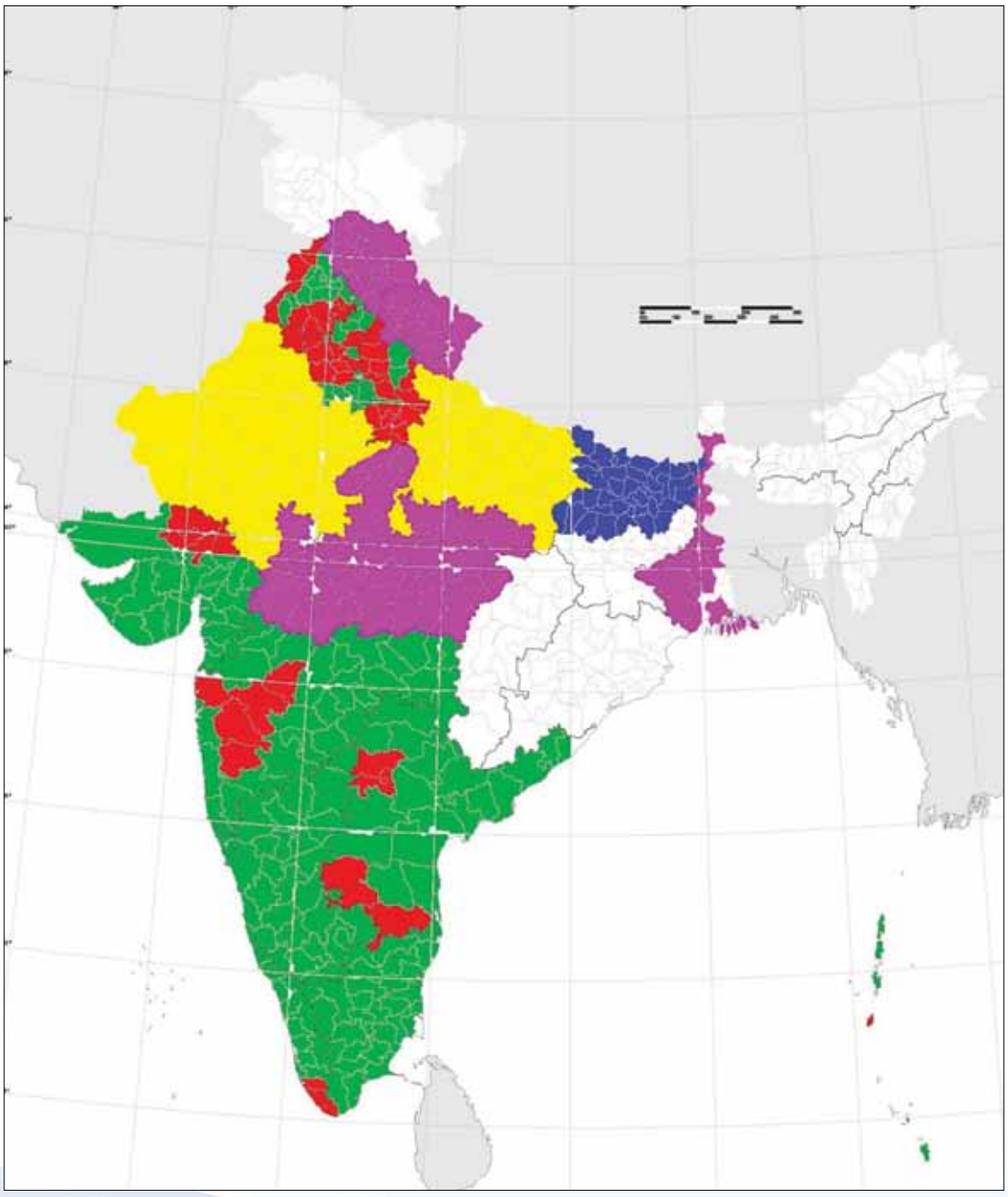
Eight villages of Andaman & Nicobar were covered under FMDCP in Phase I and later, entire Andaman & Nicobar Island was included in Phase II.

Andaman & Nicobar Islands (Phase I &II)

Round	Vaccination	Number & % animals showing titres ≥1.8 log10 against FMDV						
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
3	154	162	40(25.9)	97(60)	5(2.8)	37(20.3)	52(34.0)	118(73.6)
4	149	146	50(33.5)	94(64.6)	50(33.5)	96(65.9)	35(23.4)	101(67.6)
5	126	122	72(57.2)	68(55.8)	62(50.8)	64(52.5)	54(44.3)	62(50.8)
6	270	270	50 (18.5)	80 (29.6)	66 (24.4)	104 (38.4)	28 (10.2)	36 (13.2)
7	265	265	112 (42.3)	174 (65.7)	82 (30.9)	110 (41.5)	56 (21.1)	66 (24.9)
8	251	251	53(21.11)	102(40.63)	18(7.2)	49(19.52)	47(18.72)	85(33.86)

9	228	228	73(32.01)	69(30.26)	31(13.5)	35(15.35)	56(24.56)	42(18.42)
12	180	180	36(20.0)	49(27.22)	19(10.5)	40(22.22)	11(6.11)	30(16.67)
13	283	283	26(9.2)	78(27.6)	12(4.2)	52(18.4)	15(5.3)	44(15.5)
14	794	593	144(18.1)	279(47)	100(12.6)	214(36.1)	77(10.0)	194(32.7)
15	1445	1109	308(21.3)	550(49.9)	333(23)	584(52.6)	433(29.9)	674(60.7)
16	530	502	220 (41.5)	312 (62.2)	243 (45.8)	398 (79.3)	251(50.0)	394 (74.3)
17	521	461	225(42.3)	354(69.2)	302(58.0)	376(82)	286(55.0)	259(78)
18	609	496	383 (62.9)	408 (82.3)	414 (67.9)	426 (85.9)	505 (82.3)	458 (92.3)
19	556	480	337 (60.6)	351 (73.1)	355 (63.8)	422 (87.9)	404 (72.7)	416 (86.7)

Overall herd immunity and Seroconversion is good



Tamil Nadu

Only district Kanyakumari, was covered under FMDCP in Phase I (filled red) and later in rest of the districts (filled green) was included in the control programme Phase II.

Tamil Nadu (Phase I)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	100	100	28(28)	51(51)	29(29)	57(57)	24(24)	54(54)
2	100	100	23(23.0)	63(63.0)	24(24.0)	40(40.0)	18(18.0)	61(61.0)
3 & 4	180	330	59(32.7)	246(74.5)	61(33.8)	201(60.9)	45(25.0)	216(65.4)
6	160	130	30(18.7)	99(76.1)	31(23.8)	109(83.8)	28(21.5)	103(79.2)
7	300	300	35(11.7)	210(70)	34(11.3)	231(77)	36(12)	226(75.3)
8	100	100	34(34)	74(74)	40(40)	60(60)	25(25)	78(78)
9	100	100	40(40)	58(58)	45(45)	64(64)	33(33)	74(74)
10	100	100	32(32)	62(62)	45(45)	63(63)	41(41)	70(70)
11	200	200	38(19)	144(72)	31(15.5)	87(43.5)	29(14.5)	83(41.5)
14	200	200	71(35.5)	116(58)	93(46.5)	137(68.5)	92(46)	128(64)
15	200	200	92(46)	199(99.5)	115(57.5)	198(99)	120(60)	194(97)

Increase in herd immunity and Seroconversion has been observed in the district

Tamil Nadu (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	5440	5440	1860(34.2)	3417(62.8)	1351(24.8)	2561(47.1)	115(20.5)	2209(40.6)

2	5040	5240	1383(27.4)	3504(66.9)	684(13.6)	2433(46.4)	245(4.9)	979(18.7)
3	4600	4600	789(17.2)	2788(60.6)	396(8.6)	1801(39.2)	1030(22.4)	3361(73.1)
4	5801	5843	2570(44.3)	4547(77.8)	3296(56.8)	4826(82.6)	3643(62.8)	5066(86.7)
5	7199	6397	4089 (56.8)	5598(87.5)	4434(61.6)	5816(91)	4501(62.5)	5788(90.5)
6	6400	6400	5041 (79)	6180(96.6)	4230(66.1)	6028(94.2)	5002(78.2)	6240(97.5)
7	6400	6400	5332 (83.3)	6180 (96.6)	5016 (78.4)	6028 (94.2)	5572 (87.1)	6240 (97.5)
8	6400	6400	5480 (85.6)	6287 (98.2)	5348 (83.6)	6259 (97.8)	5845 (91.3)	6322 (98.8)
9	6400	6400	5517 (86.2)	6224 (97.3)	5230 (81.7)	6126 (95.7)	5547 (86.7)	6282 (98.2)

Increase in herd immunity and very good seroconversion has been observed

Puducherry

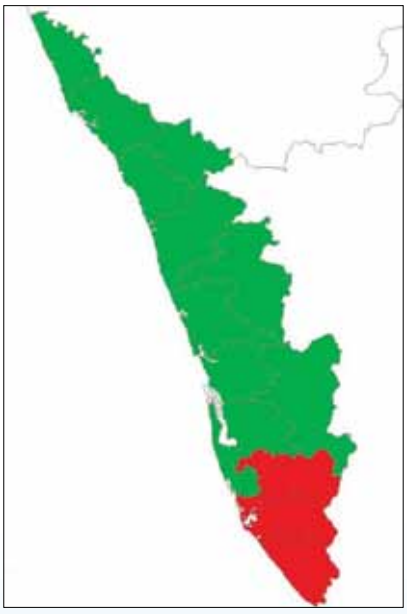
Puducherry (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	30	55	16(44.4)	24(66.7)	9(25.0)	20(55.6)	5(13.9)	11(30.6)
2	38	38	16(42.1)	20(52.6)	10(26.3)	14(36.8)	-	18(21.1)
3	46	46	21(45.7)	29(63.0)	7(15.2)	20(43.5)	26(56.5)	30(65.2)
6	246	246	214(87.0)	237(96.3)	182(74.0)	232(94.3)	213(87)	235(95.5)
7	243	243	231(95.1)	233(96.0)	147(60.4)	209(86.0)	225(93)	231(95.1)
10	275	275	242(88.0)	261(94.9)	202(73.5)	238(86.5)	236(85.8)	255(92.7)

Serum samples of round 4, 5, 8 and 9 were not available

Kerala

Three districts of Kerala namely, Trivandrum, Kollam and Pathanamthitta were covered under FMDCP in Phase I (filled red) and later, eleven districts (filled green) were included Phase II.



Kerala (Phase I).

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1 & 2 & 4	483	496	158(32.7)	255(51.4)	140(29.0)	236(47.5)	165(34.2)	280(56.4)
5	290	290	67(23.1)	197(67.9)	52(17.9)	171(58.9)	61(21.0)	211(72.7)
6	70	70	49 (20.4)	185(77.1)	41(17.1)	169(70.4)	38(15.8)	171(71.3)
7	300	300	48 (16.0)	208(69.3)	43 (14.3)	213 (71	52 (17.3)	210(70.0)
8 & 9	600	600	226(37.6)	395(65.8)	265(44.2)	341(56.8)	260(43.3)	397(66.2)
10	400	100	160(40)	59(59)	145(36.3)	66(66)	150(37.5)	53(53)
11	352	315	122(19)	122(19)	122(19)	115(17.2)	96(14.4)	88(13.2)
12	500	500	59(11.8)	202(40.4)	73(14.6)	197(39.4)	63(12.6)	153(30.6)
13	150	150	11(7.3)	42(28)	13(8.7)	39(26)	13(8.7)	41(27.3)
14	546	526	73(13.4)	74(14.1)	108(20)	123(23.4)	123(22.5)	200(38)
15	598	553	129(21.6)	286(51.7)	190(31.8)	327(59.1)	313(52.3)	432(78.1)
16	2789	2738	1498(53.7)	2479(90.5)	1425(51.1)	2164(79)	1709(61.3)	2415(88.2)
17	2791	2678	2137(76.6)	2173(81.1)	1786(64)	2462(92)	2184(78.3)	2600(97.1)
18	2800	2800	2303 (82.3)	2575 (92.0)	2145 (76.6)	2441(87.2)	2467 (88.1)	2686(95.9)

Overall herd immunity is poor in Kerala before phase XV, but there after increase in herd immunity and better seroconversion is observed

Kerala (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2	676	180	84(12.4)	65(36.1)	105(15.5)	65(36.1)	65(9.6)	61(34)
3	1631	1474	199(12.2)	525(35.6)	178(10.9)	484(32.8)	135(8.3)	376(25.5)
4	2378	2109	308(13)	526(25)	362(15.2)	633(30)	404(17)	735(35)
5	2043	1941	400(20)	991(51.1)	505(24.7)	1135(58.5)	922(45.1)	1364(70.3)

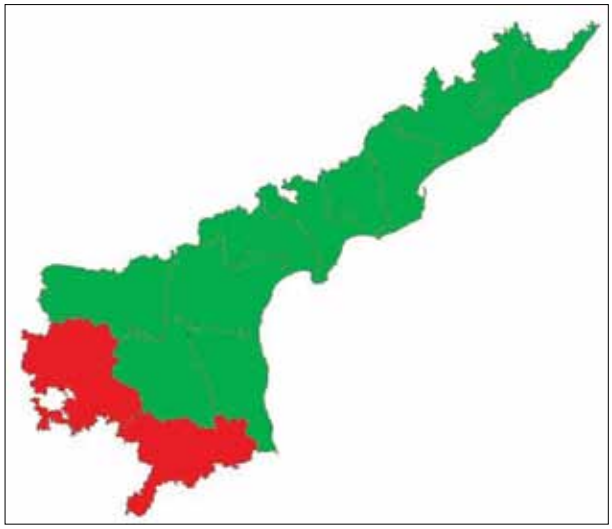
Overall herd immunity is poor in Kerala

Lakshadweep (Phase II)

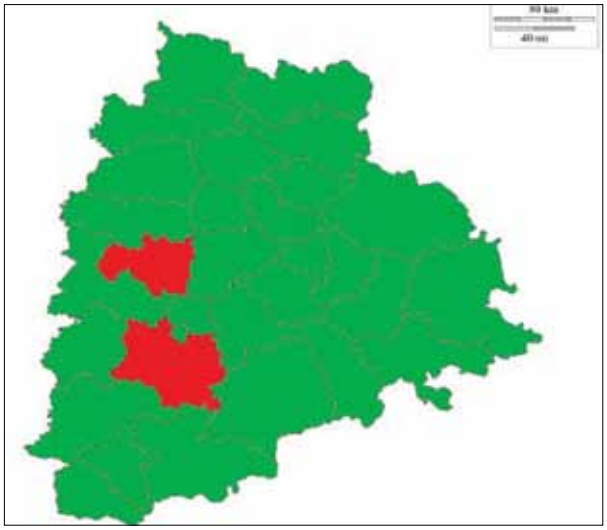
Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	107	107	45(42.1)	80(74.8)	16(15)	63(58.9)	35(32.7)	50(46.7)

Andhra Pradesh/Telengana

Two districts of Andhra Pradesh (Ananthapur, Chitoor) and two districts of Telengana (Medak and Rangareddy) are covered under FMDCP in Phase I (filled red) and rest of the districts (filled green, 11 districts of Andhra Pradesh and 29 districts of Telengana) were included in Phase II.



Andhra Pradesh



Telengana

Andhra Pradesh (Phase I)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Serotype O		Serotype A		Serotype Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	800	800	83 (10.3)	340 (42.5)	43 (5.3)	244 (30.5)	92 (11.5)	340 (42.5)
2	800	800	N.A.	434 (54.2)	N.A.	498 (62.3)	N.A.	438 (54.7)
3	800	800	210 (26.2)	286 (35.7)	395 (49.3)	532 (66.5)	306 38.2)	422 (52.7)
4	800	800	281 (35.1)	374 (46.8)	465 (58.1)	617 (77.1)	329 41.1)	518 (64.8)
5	800	800	247 (30.8)	440 (55)	466 (58.2)	574 (71.8)	343(42.8)	450 (56.3)
6	800	800	275 (34.3)	490 (61.3)	554 (69.2)	690 (86.3)	446 55.7)	634 (79.3)
7	800	800	274 (34.0)	483 (60.3)	349 (44.0)	540 (67.5)	391(48.8)	518 (64.7)
8	800	800	356 (44.5)	594 (74.0)	415 (51.8)	624 (78.0)	333(41.6)	527 (65.8)
9	800	800	422 (52.8)	673(84.1)	329 (41.1)	534 (66.8)	287(35.9)	534 (66.8)
10	800	800	502(62.7)	635(79.3)	368(46)	575(71.8)	411(51.3)	602(75.2)
11	800	800	398(49.75)	617(77.1)	356(44.5)	600(75)	333(41.6)	568(71.5)
12	800	800	387(48.4)	568(71)	266(33.25)	483(60.4)	177(22.1)	367(45.9)
13	800	800	537(67.1)	654(81.8)	438(54.8)	602(75.3)	315(39.3)	498(62.3)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Serotype O		Serotype A		Serotype Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
14	800	800	366(45.7)	634(79.2)	186(23.3)	446(54.7)	100(12.5)	389(48.6)
15	800	800	464(58)	578(72.2)	605(75.6)	733(91.6)	626(78.2)	726(90.7)
16	800	800	503(62.8)	680(85)	675(84.3)	773(96.6)	711(88.8)	796(99.5)
17	800	800	593(74.1)	665(83.1)	495(62)	563(70.4)	560(70)	613(76.6)
18	800	800	547(68.4)	749(93.8)	502(62.8)	711(89)	535(67)	743(93.0)
19	400	400	297(74.3)	369(89.8)	236(69.0)	365(91.3)	310(77.5)	380(95.0)

Andhra Pradesh (Phase II)

Round	Vaccination		Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	3600	3600	1043(29)	2396(66.5)	648(18)	2030(56.4)	419(13.1)	1709(47.5)
2	3480	3480	1435(41.2)	2381(68.4)	1026(29.5)	2054(59)	595(17.1)	1499(43.1)
3	3600	3600	1392(38.6)	2498(69.3)	750(20.8)	1661(46.1)	393(10.9)	1162(32.2)
4	3600	3600	1364(38)	2354(65.4)	1356(37.7)	2821(78.4)	1663(46.2)	2788(77.4)
5	3600	3600	1546(42.9)	2478(68.6)	2292(63.6)	3153(87.5)	2574(71.5)	3239(89.9)
6	3600	3600	2190(60.8)	2867(79.6)	1997(55.5)	2675(74.3)	2211(61.4)	2752(76.4)
7	3600	3600	2580(71.7)	3069(85.3)	2186(60.7)	2862(79.5)	2487(69.1)	3102(86.2)
8	3200	3200	2546(79.6)	2890(90.3)	2095(65.5)	2731(85.3)	2459(76.8)	2877(89.9)
9	1800	1800	1430(79.4)	1649(91.6)	1230(68.3)	1589(88.3)	1442(80.1)	1660(92.2)

Overall herd immunity and sero-conversion is very good in Andhra Pradesh

Telangana (Phase I).

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Serotype O		Serotype A		Serotype Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
19	383	400	339(88.5)	393(98.3)	251(65.5)	356(89.0)	338(88.3)	379(94.8)
20	400	400	318(79.5)	358(89.5)	300(75.0)	339(84.8)	329(82.3)	375(93.8)

Karnataka

Entire state of Karnataka was included under FMDCP in Phase II

Karnataka (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Serotype O		Serotype A		Serotype Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	4587	4266	1817(40)	2383(56)	687(15)	1722(40)	426(9)	1049(24.5)
2	5401	4632	2718(50)	3101(67)	1471(27)	2161(47)	1577(39)	2354(51)
3	3864	3075	2118(54.8)	1855(60.3)	1129(29.2)	1289(41.8)	2376(61.5)	2158(70.2)
4	5053	5225	2439(48.3)	3245(62.1)	3977(78.7)	4493(86)	3834(76)	4294(82.2)
5	5916	5853	1954(33)	3470(59)	3047(52)	3957(68)	3795(64)	4734(81)
6	5945	5985	3651(61)	5434(86)	3689(62)	5182(87)	4446(75)	5538(92.5)
7	5930	5930	4934(83)	5741(97)	5211(88)	5567(94)	5543(93)	5813(98)
8	5974	5994	5227(87.5)	5723(95.5)	5073(84.9)	5794(96.7)	5447(91.2)	5823(97.1)
9	NA	1996	NA	1936(97.0)	NA	1895(94.9)	NA	1958(98.1)
10	1461	1430	1073(73.4)	1241(86.8)	968(66.3)	1170(81.8)	1199(82.1)	1290(90.2)

Overall herd immunity and sero-conversion is very good in Karnataka

Maharashtra

Six districts of Maharashtra namely, Ahmadnagar, Aurangabad, Pune, Satara, Mumbai and Thane were covered under FMDCP in Phase I (filled red) and later, twenty nine districts (filled green) were included in Phase II

Maharashtra (Phase I)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	844	761	173 (20.5)	456 (59.9)	151(17.9)	437 (57.4)	192 (22.8)	466 (61.2)
2	834	834	N.A.	508 (60.9)	N.A.	490 (58.6)	N.A.	553 (66.2)
3	753	799	184 (24.4)	438 (54.8)	351 (46.8)	580 (72.7)	262 (34.7)	534 (66.9)
4	789	797	191 (24.2)	417 (52.3)	517 (65.6)	679 (85.3)	278 (35.2)	509 (63.9)
5	802	772	142 (17.7)	271 (35.1)	353 (44.2)	477 (62.3)	121 (15.0)	245 (31.8)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
6	901	928	404 (44.9)	663 (71.4)	622 (69)	853 (91.9)	245 (27.2)	446 (48.1)
7	1000	1000	446 (44.6)	692 (69.2)	701 (70.1)	893 (89.3)	431 (43.1)	667 (66.7)
8	1000	1000	646 (64.6)	904 (90.4)	574 (57.4)	848 (84.8)	198 (19.8)	452 (45.2)
9	1000	1000	730(73)	951(95.1)	524(52.4)	817(81.7)	324(32.4)	695(69.5)
10	1000	1000	785(78.5)	978(97.8)	686(68.6)	935(93.5)	607(60.7)	846(84.6)
11	1000	1000	558(55.8)	916(91.6)	534(53.4)	871(87.1)	403(40.3)	837(83.7)
12	980	980	590(60.2)	894(91.2)	468(47.75)	823(83.97)	341(34.79)	730(74.48)
13	950	1050	418(44)	727(69.2)	75(7.9)	332(31.6)	58(6.1)	277(26.4)
14	1040	1037	496(48)	881(85)	400(38.5)	839(81)	426(41)	831(81)
15	1098	1098	382(34.8)	902(82.1)	598(54.5)	999(91)	661(60.2)	1018(92.7)
16	1055	1051	702(66.5)	978(93.1)	774(73.4)	991(94.3)	709(67.2)	986(93.8)
17	1062	1042	849(79.9)	1003(96.3)	560(52.7)	918(88.1)	406(38.2)	806(77.4)
18	908	888	788(86.8)	876(98.6)	636(70)	835(94)	733(80.7)	835(94)
19	1093	1099	930 (85.1)	1066(97.0)	856(78.3)	1021(92.9)	900(82.3)	1048(95.4)
20	280	300	210(75.0)	276(92.0)	253(90.4)	298(99.3)	254(90.7)	300(100)

Maharashtra (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	5988	6018	1687(28.2)	4390(72.9)	941(15.7)	3080(51.2)	382(6.4)	2310(38.4)
2	7208	7341	1849(25.7)	4890(66.6)	481(5.8)	2530(34.5)	491(6.8)	2279(31)
3	4721	4723	938(20)	2674(56.6)	1444(30.6)	2933(62.1)	2674(31.6)	3096(65.6)
4	5250	5305	1673(31)	3746(70.6)	2641(50.3)	4429(83.5)	2809(53.5)	4513(85.1)
5	4891	4891	3027(61.9)	4523(92.5)	3466(70.9)	4619(94.4)	2701(55.2)	4307(88.1)
6	5362	5362	3285(61.3)	4959(92.5)	2312(43.1)	4438()	1902(35.5)	4112(77)
7	4181	4181	2973(71.1)	3888(93)	2398(57.4)	3721(89)	2491(60)	2708(65)
8	5486	5486	3317(60.5)	4905(89.4)	3726(67.9)	5119(93.3)	3684(67.2)	5149(93.9)

Overall herd immunity and sero-conversion is very good in Maharshtra

Goa

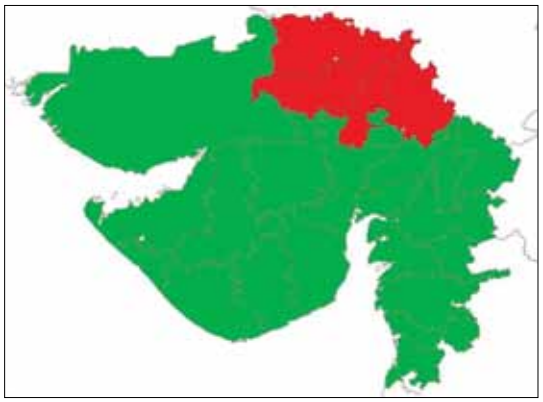
Goa was included under FMD-CP in Phase II

Goa (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	391	381	47(12)	244(86.8)	8(2)	92(24.1)	11(2.8)	92(24.1)
2	383	378	159(41.5)	316(84)	59(15.4)	234(62)	175(46)	331(88)
3	384	368	182(47.4)	302(82.1)	241(64.3)	317(86.1)	209(54.4)	316(86)
4	379	376	171(45.1)	289(77)	222(58.5)	323(86)	215(57)	320(85.1)
5	375	375	322(85.9)	371(98.9)	289(77.1)	361(96.3)	194(51.7)	338(90.1)
6	371	371	264(71.2)	362(97.6)	211(56.9)	338(91.1)	235(63.3)	343(92.5)
7	369	369	241(65.3)	343(93.0)	250(67.8)	362(98.1)	282(76.4)	364(98.6)

Gujarat

Four districts of Gujarat namely, Banaskantha, Sabarkantha, Mehsana and Patan were covered under FMDCP in Phase I (filled red) and later in Phase II, rest of the districts (filled green) were included



Gujarat (Phase I)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	382	259	50 (19.1)	116 (44.7)	59 (24.5)	128 (48.7)	42 (16.1)	114 (43.5)
3	442	357	123 (27.8)	171 (47.9)	171 (39.2)	268 (58.3)	51 (12.4)	149 (35.4)
4	497	456	113 (22.7)	277 (60.7)	184 (40.7)	355 (81.2)	73 (14.6)	218 (46.8)
5	195	202	46 (23.6)	99 (49.0)	126 (66.1)	179 (91.6)	44 (26.5)	92 (51.3)
6	395	395	119 (30.1)	223 (56.4)	249 (63.0)	317(80.2)	195 (49.3)	240 (60.7)
7	800	800	434 (54.3)	630 (78.8)	385 (48.1)	559 (69.9)	344 (43.0)	556 (69.5)
8	800	800	191 (23.9)	394 (49.3)	197 (24.6)	357 (44.6)	264 (33.0)	403 (50.4)
9	800	800	230(28.7)	618(77.2)	284(35.5)	572(71.5)	326(40.7)	595(74.4)
10	800	800	356(44.5)	620(77.5)	286(35.7)	525(65.6)	276(34.5)	535(66.9)
11	800	800	55(27.5)	76(38)	44(22)	71(35.5)	29(14.5)	49(24.5)
12	800	800	104(52)	105(52.5)	80(40)	67(33.5)	56(28)	25(12.5)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
13	2007	2029	589(29.4)	1009(49.7)	407(20.3)	784(38.6)	670(33.4)	1011(49.8)
14	1555	1201	742(47.7)	641(53.4)	513(33)	491(41)	557(35.8)	384(32)
15	800	800	641(80.1)	582(77.1)	559(70)	626(78)	647(81)	612(76.5)
16	4600	4538	2506(54.5)	3444(75.9)	2874(62.5)	3491(76.9)	3183(69.2)	3688(81.3)
17	5200	5200	3093(59.5)	3869(74.4)	3260(62.7)	3971(76.4)	3376(74.9)	4160(80)
18	3600	3600	2695(74.9)	2937(81.6)	1786(49.6)	2369(65.8)	2722(65.6)	2861(79.5)
19	600	600	491(81.8)	443(73.8)	482(80.3)	470(78.1)	456(76.0)	454(75.7)

Gujarat (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2	3194	3600	1323(41.4)	2132(59.2)	1065(33.3)	1906(60)	1191(37.3)	1940(54)
3	3900	3908	2011(51.6)	2582(66.1)	1678(43)	2320(59.4)	1598(41)	2142(54.8)
4	4400	4400	2509(57.0)	3213(73.0)	2599(59.1)	3258(74.0)	3164(71.9)	3577(81.3)

Overall herd immunity and sero-conversion is very good in Gujarat

Haryana

Eight districts of Haryana namely, Bhiwani, Fatehabad, Hisar, Jhajjar, Jind, Rohtak, Sirsa and Sonipat were covered under FMDCP in Phase I (filled red) and later, rest of the districts (filled green) were included in Phase II.

- Overall post-vac response is very good at 80% against all the three serotypes, and this has been well reflected as drastic reduction in occurrence of the disease in the state.

Haryana (Phase I)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Serotype O		Serotype A		Serotype Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2	1558	1558	NA	1065(68.3)	NA	859 (55.1)	NA	831 (53.3)
3	1585	1585	NA	1146(72.3)	NA	1007(63.6)	NA	1005(63.4)
4	1589	1552	953 (60.1)	1222(78.7)	668 (42.1)	887 (57.1)	844(53.2)	1170(75.3)
5	1600	1599	955 (59.7)	1352(84.5)	813 (50.8)	1274(79.6)	941(58.8)	1353(84.5)
6	1496	1499	995 (66.5)	1306(87.1)	895 (59.8)	1229(82.0)	844(56.4)	1118(74.6)
7	1562	1574	856(54.8)	1296 (82.3)	1021(65.3)	1380(87.6)	888 (56.8)	1317 (83.6)
8	1547	1540	949(61.3)	1289 (83.7)	877 (56.6)	992 (64.4)	765 (49.4)	1101 (71.4)
9	1497	1476	647(43.2)	1140(77.2)	590(39.4)	1022(69.2)	410(27.4)	879(59.6)
10	1420	1439	851(59.9)	1350(93.8)	615(43.3)	1003(69.7)	587(41.3)	1145(79.5)
11	1500	1464	734(48.9)	1302(88.9)	546(36.4)	1180(80.6)	455(30.3)	1109(75.8)
12	1360	1210	593(43.6)	975(80.6)	520(38.2)	989(81.7)	474(34.9)	896(74.1)
13	1590	1600	925(58.2)	654 (82.8)	218(27.6)	630(79.8)	185(23.4)	616(78.0)
14	1580	1580	627(39.7)	1327(84.0)	594(37.6)	1279(81.0)	536(33.9)	1272(80.5)
15	1600	1600	963(60.2)	1286(80.4)	856(53.5)	1207(75.4)	724(45.3)	1182(73.9)
16	1600	1600	913(57.1)	1335(83.4)	813(50.8)	1351(84.4)	983(61.4)	1409(88.1)
17	1597	1600	935(58.5)	1434(89.6)	1044(65.4)	1460(91.3)	1323(82.8)	1556(97.3)
18	1600	1600	1153(72.1)	1547(63.8)	1020(69.1)	1476(96.7)	1106(92.3)	1541(96.3)
19	1600	1600	1332(83.3)	1569(98.1)	1305(81.6)	1546(96.6)	1327(82.9)	1590(99.4)
20	1700	1100	1267 (74.5)	1055 (96.0)	1215 (71.5)	1005 (91.4)	1433 (84.3)	1079 (98.1)

Haryana (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Serotype O		Serotype A		Serotype Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	3086	2354	1049(43.9)	1790(76.1)	988(41.4)	1789(76.0)	715(30.0)	1469(62.4)
2	2586	2594	1081(41.8)	1876(73.5)	986(38.1)	727(28.1)	986(38.1)	1537(60.2)
3	2555	2562	1092(42.5)	1809(71.2)	1113(43.3)	1856(73.1)	650(25.3)	1576(62.1)
4	2565	2575	1043(40.1)	2049(79.5)	893(34.8)	1811(70.3)	840(32.7)	1700(66)
5	2600	2600	1210(46.5)	1867(71.8)	1178(45.3)	1638(63)	1010(39)	1709(66)
6	2580	2580	1171(45.4)	2063(80)	1455(56.4)	2161(83.8)	1865(72.3)	2341(90.7)
7	2558	2597	1755(68)	2285(88)	1895(74.1)	2160(83.2)	2050(80.1)	2483(95.6)
10	2000	200	1347 (67.4)	192 (96.0)	1343 (67.2)	191 (95.5)	1555 (77.8)	199 (99.5)

Delhi

Delhi was included under FMD-CP in Phase I

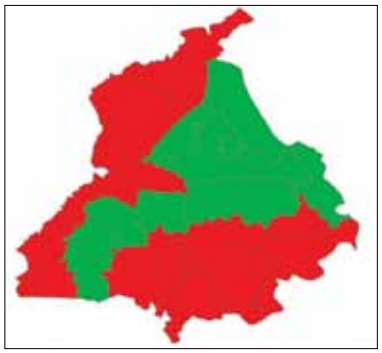
Delhi (Phase I)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	50	50	26 (53)	50 (100)	13 (26)	47 (94)	17 (34)	48 (96)
2	24	24	22 (91)	23 (96)	12 (40)	15 (62)	23 (95)	22 (86)
3	50	50	47 (94)	49 (98)	30 (60)	40 (80)	43 (86)	46 (92)
4	50	46	38 (76)	38 (82.6)	14 (28)	40 (86.9)	27 (54)	41 (89.1)
5	44	53	26 (59)	47 (88.6)	23 (52.2)	37 (69.8)	32 (72.7)	41 (77.3)
6	98	98	76 (77.5)	97 (98.9)	60 (61.2)	93 (94.9)	71(72.4)	97 (98.9)
7	50	50	39(78)	44(88)	33(66)	43(86)	25(50)	41(82)
8	100	100	92 (92)	100 (100)	66 (66)	86 (86)	83 (83)	98 (98)
9	100	NA	57(57)	NA	65(65)	NA	33(33)	NA
11	200	NA	172(86)	NA	100(50)	NA	91(45.5)	NA
13	100	100	98(98)	98(98)	95(95)	100(100)	87(87)	100(100)
14	NA	200	NA	170(85)	NA	179(89.5)	NA	153(76.5)
15	200	200	157(78.5)	171(85.5)	124(62)	158(79)	143(71.5)	156(78)
18	200	200	154(77)	196(98)	107(53.5)	177(88.5)	161(80.5)	193(96.5)
19	200	200	137 (68.5)	184 (92)	140 (70)	184 (92)	162 (81)	183 (91.5)

Herd immunity is very good at >80%.

Punjab

Eight districts of Punjab namely, Amritsar, Bhatinda, Fatehgarh Sahib, Ferozpur, Mansa, Sangrur, Patiala and Gurdaspur were covered under FMDCP in Phase I (filled red) and later, rest of the districts (filled green) was included in Phase II



Punjab (Phase I)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	-	742	N.A.	187(25.2)	N.A.	90(11.5)	N.A.	273(49.5)
2	-	500	N.A.	219(43.8)	N.A.	113(20.9)	N.A.	279(58.1)
3	1084	1365	915(84.4)	1175(86.1)	816(75.3)	1007(73.8)	437(40.2)	573(42.0)
4	1291	978	988(76.5)	792 (81.0)	794(61.5)	627 (64.1)	694 (53.8)	356(36.4)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
5	1370	1139	477(34.8)	621(54.5)	445(32.8)	630(53.7)	513(38.5)	690(60.1)
6	1509	1568	653 (43.3)	944 (60.2)	654 (43.3)	921 (58.7)	496 (32.9)	743 (47.4)
7	1265	1432	520 (41.1)	898 (62.7)	356 (28.1)	639 (44.6)	448 (35.4)	696 (48.6)
8	984	1125	580(58.9)	825(73.33)	410(41.7)	643(57.2)	452(45.9)	741(65.9)
9	1558	1546	1035(66.4)	1193(77.1)	831(53.3)	978(63.4)	926(59.4)	1132(73.2)
10	1592	1592	1030(64.7)	1231(77.3)	904(56.8)	1098(67.0)	970(61.0)	1156(72.6)
11	1600	1600	991(61.9)	1186(74.1)	881(55.1)	1075(67.2)	965(60.3)	1142(71.4)
12	1600	1556	1033(64.5)	1115(71.6)	914(57.1)	1026(65.9)	897(56.1)	NT
13	1660	1605	1001(60.3)	934(58.2)	960(57.8)	1057(65.9)	1024(61.7)	1241(77.7)
14	1528	1333	812(53.1)	866(65.0)	905(59.2)	728(54.6)	1142(74.7)	1067(80.0)
15	1697	1555	1045(61.5)	1126(72.4)	1179(69.5)	1247(80.2)	1456(85.8)	1435(92.3)
16	1310	1532	859(65.2)	1054(69.7)	985(75.2)	1202(78.8)	1083(82.3)	1379(90.7)
17	1560	1500	973(62.4)	1133(75.5)	1056(67.7)	1170(78.0)	983(63.0)	1166(77.7)
18	1578	1540	1091(69.1)	1206(78.3)	1042(65.7)	1119(72.7)	995(63.1)	1140(74.0)
19	580		428(73.8)		374(64.5)		353(60.9)	

Overall Seroconversion and herd immunity is good.

Punjab (Phase II)

Round	Vaccination		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	1800	1800	797(44.3)	978(54.3)	704(39.1)	825(45.8)	615(34.2)	874(48.6)
2	1800	1782	1002(55.6)	1096(61.5)	902(50.1)	978(54.8)	904(50.2)	NT
3	1436	1195	940(65.5)	845(70.7)	900(62.7)	815(68.2)	908(63.2)	977(81.7)
4	2287	2110	1271(55.6)	1592(75.5)	1557(68.1)	1030(48.8)	1707(74.6)	1849(87.6)
5	1975	1705	1088(55.1)	1162(68.2)	1359(68.8)	1389(81.5)	1660(84.1)	1602(94.0)
6	1872	1990	1248(66.7)	1416(71.2)	1423(76.0)	1606(80.7)	1582(84.5)	1832(92.1)
7	2126	2105	1442(67.8)	1595(75.8)	1363(64.1)	1567(74.4)	1365(64.2)	1626(77.7)
8	2400	2289	1724(71.8)	1824(79.7)	1577(65.7)	1692(73.9)	1444(60.2)	1608(70.2)
9	698		490 (70.8)		462 (66.2)		478 (68.5)	

Overall Seroconversion and herd immunity is good, and this has been well reflected as drastic reduction in occurrence of the disease in the state.

Uttar Pradesh

Sixteen districts of UP (Agra, Aligarh, Budaun, Bulandsahar, Etah, Ferozabad, Gautam Bhuddha Nagar, Gaziabad, Hatras, J.P.Nagar, Mathura, Meerut, Baghpat, Saharanpur, Muzaffarnagar and Muradabad) are covered under FMDCP in Phase I (Red). Rest of the districts were included during the expansion in Phase III. Overall seroconversion is very poor in the state.

Uttar Pradesh (Phase I)

Round	Vaccination		Number & % animals showing titres ≥1.8 log10 against FMDV					
		Serotype O		Serotype A		Serotype Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2	139	407	0(0)	180(44.2)	0(0)	155(38.1)	0(0)	293(72.0)
3	1155	1584	399(34.5)	780(49.2)	494(42.7)	910(57.4)	490(42.4)	1138(71.8)
4	1910	1770	344(18.0)	537(30.3)	610(31.9)	866(48.9)	519(27.2)	808(45.6)
5	1440	1591	516(35.8)	715(44.9)	625(43.4)	802(50.4)	684(47.5)	786(49.4)
6	1488	1579	514(34.5)	968 (61.3)	520 (34.9)	826 (52.3)	400 (26.9)	838 (53.1)
7	2833	2075	706 (24.9)	911 (43.9)	597 (21.1)	808 (38.9)	740 (26.1)	930 (44.8)
8	1904	2744	707(37.1)	1550(56.5)	502(26.4)	1310(47.7)	617(32.41)	1288(46.9)
9	2762	3002	927(33.5)	1198(39.9)	617(22.34)	1095(36.5)	597(21.6)	1072(35.7)
11	643	2206	47(7.3)	481(21.8)	68(10.6)	321(14.6)	385(59.9)	1103(50)
12	1934	1535	184(9.5)	270(17.6)	252(13)	524(34.1)	424(21.9)	773(50.6)
13	983	2946	146(15)	955(32.4)	69(7.7)	780(26.5)	220(22.4)	1054(35.8)
14	4041	3800	2473(61.2)	2522(66.4)	2501(62)	2139(56.3)	2501(62)	1107(29)
15	3870	3968	1641(42.4)	2260(57)	1312(33.9)	2256(56.9)	1507(38.9)	2626(66.2)
16	10763	3648	4114(38.2)	1375 (37.7)	4527(42.1)	1584 (43.4)	4570(42.5)	1834 (50.3)
17	8840	NA	2721 (30.8)	NA	4343(49.1)	NA	5595(63.3)	NA

Rajasthan

All districts of Rajasthan are covered under FMDCP in Phase III.

Rajasthan (Phase III)

Round	Vaccination		Number & % animals showing titres ≥1.8 $\log_{10}$ against FMDV					
		Serotype O		Serotype A		Serotype Asia 1		
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2	1996	2298	1069(53.6)	1915(83.3)	1199(60.1)	1634(71.1)	1276(63.9)	1657(72.1)
3	1117	238	750 (67.1)	229 (96.2)	827 (74.0)	198 (83.2)	1023 (91.6)	213 (89.5)

Summary of overall sero conversion against each serotype and impact of vaccine (54 districts; FMDCP Phase I)

The herd immunity has progressively increased with minor aberrations that speak for positive impact of vaccination. Incidence/occurrence of the disease has also progressively declined in the southern region and also down to near zero in the states of Haryana and Punjab. There has been complete absence of serotype A and Asia1 during 2016-17, which is good indicator of vaccine effect. If the trend continues for some years, use of monovalent vaccine against serotype O can be encouraged. There has been case of FMD in FMD-CP districts affecting very limited number of animals and did not spread due to surrounding herd immunity. Further, there has been reduction in severity of clinical sickness. Of late, due to delay in vaccination there have been a few sporadic incidences in vaccinated areas. There have been certain problems in maintaining 6 month interval between successive vaccinations. This problem can be circumvented/compensated by using a vaccine having at least 8-12 PD50/dose. The results have been encouraging and should be further strengthened by constituting a National FMD Control Commission.

Table 10.1.1 Percent animals showing post vaccinal antibody titers of ≥1.8 log10 against FMD virus (Phase I, 54 districts)

Round	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	27.3	53.5	22.0	49.5	23.8	57.6
2	36.7	60.2	23.3	48.4	36.8	63.5
3	43.7	64.3	43.7	61.5	39.1	62.6
4	41.2	62.3	42.4	67.5	36.2	61.1
5	38.0	39.3	46.3	65.6	40.8	59.4
6	38.9	67.9	46.6	73.9	36.8	62.6
7	39.7	68.5	39.4	67.1	35.1	62.8
8	42.3	68.7	37	58.6	33.5	57
9	63.7	85.6	52	73.3	52.6	73
10	63.4	87.4	50.6	74.7	48.9	76.7
11	44.1	57.8	37.8	51.5	39.3	59.3
12	36.6	55.3	31.8	54.9	30	39.3
13	44.0	48.8	26.8	41.4	30.4	46.3
14	48.2	67.7	45.5	58.9	47.3	52.7
15	46.5	71.6	50.1	76.0	54.4	78.5
16	47.8	77.0	52.5	78.4	57.0	85.9
17	66.6	80.6	63.4	82.8	67.3	84.8
18	75.1	89.0	57.0	78.6	74.0	87.1
19	75.5	92.8	69.7	93.4	73.4	96.0
20	75.8	94.8	71.0	93.6	87.2	97.0

Table 10.1.2 Percent animals showing post vaccinal antibody titers of ≥1.8 log_{10} against FMD virus (Phase II, 167 districts)

Round	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1	33.4	65.3	21.4	50.7	10.9	40.7
2	37.5	66.5	23.5	46.3	20.5	38.2
3	36.5	63.1	28.3	52.1	34.2	56.1
4	39.4	66.8	50.5	75.3	53.7	77.8
5	45.9	74.1	57.3	81.1	60.4	84.4
6	64.5	90.0	57.4	86.0	65.0	87.8
7	77.7	93.2	73.6	89.5	80.2	89.7
8	84.2	95.1	76.8	94.5	88.1	96.2
9	84.7	96.2	78.8	94.6	85.2	97.1

10.2 Sero-monitoring in animals vaccinated under ASCAD/RKVY programmes

State	T	T	Pre-Vac						Post-Vac					
			O	%	A	%	Asia1	%	O	%	A	%	Asia1	%
Assam	245	510	32	13.06	22	9.0	23	9.4	416	81.6	382	74.9	379	74.3
Mizoram	177	172	124	70.06	119	67.2	140	79.1	159	92.4	151	87.8	166	96.5
Manipur	384	384	61	15.89	59	15.4	55	14.3	336	87.5	332	86.5	337	87.8
Tripura	55	55	30	54.55	33	60.0	36	65.5	41	74.5	43	78.2	45	81.8
NRC on Mithun Nagaland	59	34	42	71.19	17	28.8	47	79.7	27	79.4	15	44.1	22	64.7
Himachal Pradesh	120	72	58	48.33	74	61.7	65	54.2	19	26.4	20	27.8	23	31.9
Total	1040	1227	347	33.37	324	31.2	366	35.2	998	81.3	943	76.9	972	79.2

Sampling was done at random, and not as per FMD-CP format. Percentage serum samples having protective titre against serotypes O, A and Asia 1 is given in parenthesis

Productions and Supply of Diagnostic Reagents

11

11 Productions and Supply of Diagnostic Reagents

For production of reagents, the vaccine virus strains {O (INDR2/1975), Asia1 (IND 63/1972),) and A (IND40/2000)} were bulk produced in roller culture vessels and purified by density gradient centrifugation. Antibodies against purified virus was raised and titrated against homologous as well as heterologous virus. Freeze dried and standardized serum antibodies and known positive antigen (killed) of all three serotypes were supplied to all the centres and network units for use in virus serotyping ELISA and DIVA ELISA. The kits have been supplied to the AICRP units FMD Regional centers/network units for sero-surveillance and monitoring of FMD and also to the SAARC Countries.

Table 11.1 Supply of Diagnostic kits

	LPBE	S-ELISA	DIVA
2009-10	80,000	7,000	54,485
2010-11	82,800	9,000	71,940
2011-12	1,54,600	10,000	61,670
2012-13	1,77,850	16,500	85,350
2013-14	2,36,640	21,500	87,850
2014-15	2,71,960	3,000	79,800
2015-16	1,65,520	7,500	50,380
2016-17	-	6,000	94,380

FMD Serotying kits for testing 500 samples were supplied in December, 2016 to Sri Lanka

12 Research Projects

S. No.	Title	PI	Co-PI	Duration	Institute code
1.	Cataloguing and Maintenance of National Foot and Mouth Disease virus repository during 2017-18	B. Pattnaik	Saravanan S R. Ranjan J. K. Biswal	2017-18	DFMD/1/2017-18
2.	Production, standardization and supply of diagnostic reagents for Foot and Mouth Disease virus diagnosis and surveillance during 2017-18.	R. Ranjan	M. Rout Sagar A. Khulape	2017-18	DFMD/2/2017-18
3.	Random serosurveillance of FMD in India during 2017-18.	R. Ranjan	M Rout J. K. Biswal	2017-18	DFMD/3/2017-18
4.	Seromonitoring of pre and post vaccinal immunity against Foot and Mouth Disease virus during 2017-18.	Saravanan S	J. K. Biswal R. Ranjan	2017-18	DFMD/4/2017-18
5.	Evolutionary and antigenic analysis of Foot and Mouth Disease virus serotype A during 2017-18.	J. K. Biswal	R. Ranjan M. Rout	2017-18	DFMD/5/2017-18
6.	Genetic and antigenic analysis of Foot and Mouth Disease virus serotype Asia1 during 2017-18.	Sagar A. Khulape	Saravanan S R. Ranjan	2017-18	DFMD/6/2017-18
7.	Molecular Epidemiology and antigenic analysis of foot and mouth disease virus serotype O from India during 2017-18.	Saravanan S.	Sagar A. Khulape M. Rout	2017-18	DFMD/7/2017-18
8.	Epidemiology of Foot and Mouth Disease in small ruminants and pigs in India during 2017-18.	M. Rout	Saravanan S	2017-18	DFMD/8/2017-18
9.	Deep sequencing of FMD virus genome during 2017-18.	Sagar A. Khulape	Saravanan S. J.K. Biswal	2017-18	DFMD/9/2017-18
10.	Assessment of persistence of foot and mouth virus in animal through meta genomic approach	Sagar A. Khulape	R. Ranjan	2017-18	DFMD/10/2017-18
11.	Detection of subclinical infection of foot-and-mouth disease virus in goat under natural condition	R. Ranjan	J.K. Biswal	2017-19	DFMD/11/2017-18
12.	Development and validation of solid-phase competitive ELISA (SPCE) for detection of antibody against FMDV serotype O, A and Asia1	J. K. Biswal	Saravanan S. R. Ranjan	2017-18	DFMD/12/2017-18
13.	Understanding FMD viral ecology and landscape epidemiology towards control and eradication.	R. Ranjan	Saravanan S. M. Rout J.K. Biswal Sagar A. Khulape	2016-17 (To be extended)	ICAR-DFMD & PIADC, USA collaborative project
14.	Evaluation of selected foot and mouth disease virus strains for their potential as vaccine	B P Sreenivasa (IVRI)	J K Biswal Saravanan S R Ranjan A Sanyal (IVRI)	2016-18	ICAR-DFMD & ICAR-IVRI collaborative project

13 Publications, Awards and Honours

Research Papers

Biswal JK, Ranjan R, Pattnaik B (2016) Chimeric foot-and-mouth disease virus serotype O displaying a serotype Asia1 antigenic epitope at the surface. **Biotechnol Lett** (Springer). 38(9):1509-17

Biswal JK, Subramaniam S, Ranjan R, Pattnaik B (2016) Evaluation of FTA® card for the rescue of infectious foot-and-mouth disease virus by chemical transfection of extracted RNA in cultured cells. **Mol Cell Probes** (Elsevier). 30(4):225-30

Biswal JK, Subramaniam S, Ranjan R, Pattnaik B (2016) Partial deletion of stem-loop 2 in the 3' untranslated region of foot-and-mouth disease virus identifies a region that is dispensable for virus replication. **Arch Virol** (Springer). 161(8):2285-90

Biswal JK, Ranjan R, Das B, Subramaniam S, Pattnaik B (2017) The direct boil RT-mPCR: A simple and rapid method for detection of foot-and-mouth disease virus genome in clinical samples without nucleic acid extraction. **Indian J. Vet. Pathol** (Diva Enterprises Pvt.Ltd). 41(1) : 12-17, 2017

Dash L, Subramaniam S, Khulape SA, Prusty B, Pargai K, Narnaware SD, Patil NV, Pattnaik B (2016). Development of naïve phage display VHH libraries from Indian camel. **Indian J Anim Sci** (ICAR). 86 (8): 1–00

Mohanty NN, Das B, Sarangi LN, Subramaniam S, Mohapatra JK, Panda HK (2016) Isolation and characterization of foot-and-mouth disease virus from Odisha, India. **Trop Biomed** (SCImago). 33(4): 753–760

Ranjan R, Biswal JK, Sharma GK, Sharma AK, Singh KP, Misri J, Pattnaik B (2016). Use of nucleic acid recognition methods (m-PCR and RT-LAMP) for the detection of foot-and-mouth disease virus excreted in cow milk. **Indian J Anim Sci** (ICAR). 86 (8): 865–868

Ranjan R, Biswal JK, Sharma JK, Misri J, Pattnaik B (2016). Profiling of bovine toll like receptors (TLRs) in foot and mouth disease vaccinated cattle. **Indian J Anim Sci** (ICAR).86: 4

Ranjan R, Biswal JK, Singh KP, Pattnaik B (2016) Optimization of fluorescent antibody techniques for demonstration of foot-and-mouth disease virus in bovine tongue epithelium and dorsal soft palate. **Indian J Vet Pathol** (Diva Enterprises Pvt.Ltd). 40 (4)

Rout M, Doley J, Maiti S, Bera AK,Chatterjee N, Bhattacharya D, Mohapatra JK (2016). Evidence of foot and mouth disease virus infection in Yaks reared in a farm of Arunachal Pradesh. **Indian J Vet Pathol** (Diva Enterprises Pvt.Ltd). 40(3):284-286

Rout M, Nair NS, Das B, Subramaniam S, Mohapatra JK, Pattnaik B (2016). Foot-and-mouth disease in elephants in Kerala state of India during 2013. **Indian J Anim Sci** (ICAR). 86 (6): 627–631

Rout M, Senapati MR, Mohapatra JK, Mohanty TK (2016) Serological study for detection of foot-and-mouth disease virus activity in breeding bulls of an elite herd of North India. **Indian J Vet Pathol** (Diva Enterprises Pvt.Ltd). 40(3):254-256

Rout M, Subramaniam S, Das B, Mohapatra JK, Dash BB, Sanyal A, Pattnaik B (2016) Foot-and-mouth disease in wildlife population of India. **Indian J Anim Res** (Diva Enterprises Pvt.Ltd). doi: http://dx.doi.org/10.18805/ijar.11333

Rout M, Subramaniam S, Mohapatra JK, Pattnaik B (2016) Clinico-molecular diagnosis and phylogenetic investigation of foot-and-mouth disease in small ruminant population of India. **Small Ruminant Res** (Elsevier). 144 (2016) 1–5

Rout M, Senapati MR, Mohapatra JK, Mohanty TK, Kimothi SP, Sanyal A (2016) Demonstration of foot-and-mouth disease virus infection specific non-structural protein-antibodies in a vaccinated herd comprising cattle, buffaloes and goats in north India. **Indian J Anim Sci** (ICAR). 86 (11), 1238-1241.

Research Papers with inter-institutional collaborations

Ranjan R, Biswal JK, Subramaniam S, Singh KP, Stenfeldt C, Rodriguez LL, Pattnaik B, Arzt J (2016). Foot-and-Mouth Disease Virus-Associated Abortion and Vertical Transmission following Acute Infection in Cattle under Natural Conditions. **PLoS One (plos.org)**.11(12):e0167163. doi: 10.1371

Hayer SS, Ranjan R, Biswal JK, Subramaniam S, Mohapatra JK, Sharma GK, Rout M, Dash BB, Das B, Prusty BR, Sharma AK, Stenfeldt C, Perez A, Rodriguez LL, Pattnaik B, VanderWaal K, Arzt J (2017) Quantitative characteristics of the foot-and-mouth disease carrier state under natural conditions in India. **Transbound Emerg Dis** (Blackwell Verlag GmbH). doi: 101111/tbed12627

Sreenivasa BP, Mohapatra JK, Pauszek SJ, Koster M, Dhanya VC, Tamil Selvan RP, Hosamani M, Saravanan P, Basagoudanavar SH, de los Santos T, Venkataramanan R, Rodriguez LL, Grubman MJ (2017) Recombinant human adenovirus-5 expressing capsid proteins of Indian vaccine strains of foot-and-mouth disease virus elicits effective antibody response in cattle. **Veterinary Microbiology** 203: 196-201

Mahto DK, Sinha AK, Sinha SK, Shivani S, Ranjan R (2017). Influence of Inclusion of Different Levels of Okara Meal in Replacement of Groundnut Cake in the Diet on Nutrient Utilization and Growth Performance in Japanese Quails. **Indian J. Anim. Nutr** (Diva Enterprises Pvt. Ltd). 34 (1): 99-103.

Technical/Popular Articles/leaflet/folder

Ranjan R, Biswal JK, Sharma GK, Pattnaik B (2016). A Review on Foot-and-mouth disease: pathology, diagnosis and its management. **Indian J Vet Pathol** (Diva Enterprises Pvt.Ltd). 40(2): 105-115.

Rout M (2016) Overview on Pathology and Pathogenesis of Foot-and-Mouth Disease in Small Ruminants. **J Immunol Immunopathol** (Diva Enterprises Pvt.Ltd). 18(1):1-12

Ranjan R (2016). Farmers play an important role in control of foot and mouth disease. In English-folder.

Ranjan R (2016). Quarterly FMD bulletin.

Ranjan R (2017). Thnaila Rog: Karan evan Bchav. Kisan Gyan.

Book Chapters

Ranjan R, Biswal JK and Pattnaik B (2016). Persistence of foot-and-mouth disease virus. Advances in Animal Sciences and Biomedicine in 21st Century. International Academy of Biosciences (IAB), pp: 167-172.

Research abstracts

Open Session of the Standing Technical and Research Committees of the European Commission for the Control of Foot-and-Mouth Disease. Portugal. 26th-28th October 2016

Biswal JK, Ranjan R, Das B, Subramaniam S, Arzt J, Rodriguez Luis, Pattnaik B. Genetic and Antigenic Variation of FMD Disease Virus during Persistence in naturally infected Cattle and Buffalo.

Ranjan R, Biswal JK, Subramaniam S, Dash BB, Nandkumar S, Rodriguez L, Arzt J, Pattnaik B. Localization of Foot-and-Mouth disease RNA and viral antigens in different tissues from apparently healthy cattle and buffalo under natural condition in India.

Subramaniam S, Biswal JK, Das B, Ranjan R., Pattnaik B. A positively charged residue at antigenic site 4 of foot-and-mouth disease virus serotype O confer complete resistance to neutralization.

Vander-Waal K, Hayer S, Kinsley A, Iglesias

I, Sampedro F, Goldsmith T, Omondi G, Sangula A, Obanda V, Gakuya F, Mwiine F, Ranjan R, Biswal JK, Pattnaik B, Arzt J, Rieder E, Rodriguez L, Perez A. Epedemiological modeling of FMDV in endemic and epidemic settings: A review of research at the university of Minnesota.

International Conference on Global Perspectives in Virus Disease Management. VIROCON-2016, 8-10 December, 2016, ICAR-IIHR, Bengaluru, India

Biswal JK, Ranjan R, Subramaniam S, Pattnaik B. The cellular chaperone heat shock protein-90 facilitates foot and mouth disease viral particles assembly and a potential target for antiviral therapy.

Khulape SA, Subramaniam S, Pattnaik B. Molecular pathotyping and Evolutionary dynamics of type Asia1 foot and mouth disease virus isolates of Mithun of north-east India. International Conference on Global Perspectives in Virus Disease Management. VIROCON-2016, 8-10 December, 2016, ICAR-IIHR, Bengaluru.

Ranjan R, Biswal JK, Subramaniam S, Pattnaik B. Persistence of Foot-and-Mouth Disease virus in cattle and buffalo.

Subramaniam S, Das B, Biswal JK, Ranjan R, Dash BB, Pattnaik (B). Serial cytolytic passage of foot and mouth disease virus under non-immune pressure resulted in change of antigenicity.

33rd Annual Conference of Indian Association of Veterinary Pathologists & 7th Annual Meeting of Indian College of Veterinary Pathologists and National symposium on "Innovative Approaches for Diagnosis and Control of Emerging and Re-emerging Diseases of Livestock, Poultry and Fish" at Department of Veterinary Pathology, college of Veterinary Science & AH, Chhattisgarh Kamdhenu Vishwavidyalaya, Anjora, Durg-491001, Chhattisgarh, India, November 9-11, 2016.

Ranjan R, Biswal JK, Dash BB, Pattnaik B. Dorsal soft palate and dorsal nasopharynx: Primary site of persistence of foot and mouth disease virus in buffalo under natural condition

Ranjan R, Biswal JK, Dash BB, Pattnaik B. Conventional and new approach for diagnosis of foot and mouth disease virus.

Conference Awards

Dr. B.S. Rajya Memorial Award, 2015 for the best short/rapid communication entitled- Isolation and characterization of foot-and-mouth disease virus from a captive Indian elephant (*Elephas maximus*). Biswal JK, Subramaniam S, Ranjan R, Sharma GK, Pattnaik B. *Indian Journal of Veterinary Pathology,* 39 (4): 376-379, 2015. The Indian Association of Veterinary Pathologists during the Annual conference held at Chhattisgarh Kamdhenu vishwavidhyalaya, Anjora, Durg (CG), 9-11th November, 2016.

Best oral presentation at International Conference on Global Perspectives in Virus Disease Management, for the presentation on Serial cytolytic passage of foot and mouth disease virus under non-immune pressure resulted in change of antigenicity at, VIROCON 2016, 8-10 December, ICAR-IIHR, Bengaluru. Authors: Subramaniam S, Das B, Biswal JK, Ranjan R, Dash BB, Pattnaik B.

Late Dr. M. N. Kulkarni Memorial Award for best Research Paper presentation for the paper entitled 'The naïve phage display variable heavy chain libraries from Camelus dromederius showing specificity to Foot and Mouth disease serotype Asia1' Dash L, Subramaniam S, Khulape SA, Prusty B, Pargai K, Narnaware SD, Patil NV and Pattnaik B. presented during XXIX annual Convention of IAVMI and global symposium on Animal Health: Newer Technologies and their applications at Guwahati, 12-14 February 2016.

Radio Talk

Dr Khulape SA delivered radio talk for farmers on topic "Foot and Mouth Disease Management" for community radio station ShardaKrishiVahini (Frequency: 90.8 MHz), aired on 08-11-2016. (Language: Marathi)

14 Human Resource Developments

Training Organized

Four training Programmes on DIVA-ELISA and one on FMD-DSS were organized, in which scientists from regional and collaborative centres of AICRP on FMD and FMD vaccine manufacturing companies.

S.No	Name of Training	Duration	No. of Person
1	Training on FMD diagnosis (DIVA ELISA)	22-25 April 2016	1
2	Training on FMD diagnosis (DIVA ELISA)	29-30 August 2016	2
3	Training on FMD Decision Support System	1-4 November 2016	1
4	Training on FMD diagnosis (DIVA ELISA)	19-21 December 2016	5

Training undergone by staff

1. Dr Ranjan R attended the Regional workshop on the application of the FAO laboratory mapping tool (LMT) in Bangkok, Thailand during 1-5 August, 2016.
2. Dr Ranjan R attended training programme on "Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR" organized by NAARM, Hyderabad with the help of Centre for Good Governance, Hyderabad during 23-25 February 2017.

Meeting/ Conference/ Symposium attended by staff

1. Dr Ranjan R and Dr Biswal JK attended open Session of the Standing Technical Committee of the European Commission for the Control of Foot-and-Mouth Disease meeting at Cascais, Portugal, 25-28 October 2016
2. Dr Biswal JK attended 12th OIE/FAO FMD Reference Laboratories Network Annual Meeting at ANSES, Paris, France during 30th November – 2nd December, 2016
3. Dr Ranjan R attended 33rd Annual Conference of Indian Association of Veterinary Pathologists & 7th Annual Meeting of Indian College of Veterinary Pathologists and National symposium on "Innovative Approaches for Diagnosis and Control of Emerging and Re-emerging Diseases of Livestock, Poultry and Fish" at Department of Veterinary Pathology, College of Veterinary Science & AH, Chhattisgarh Kamdhenu Vishwavidyalaya, Anjora, Durg-491001, Chhattisgarh, India, November 9-11, 2016.
4. Dr Ranjan R attended "3rd Regional Roadmap Meeting on PCP-FMD for SAARC Member States" held at Colombo, Sri Lanka from 14- 16 December, 2016.
5. Dr Khulape SA attended 21 days CAFT program "Computational Approaches for Next Generation Sequencing (NGS) Data Analysis in Agriculture" at Indian Agriculture Statistics Research Institute, New Delhi from February 08-28, 2017

6. Dr Khulape SA attended workshop NIC's e-Procurement solution through CPP Portal from 02 to 03 June, 2016 at Indian veterinary Research Institute, Bareilly.
7. Dr Khulape SA attended workshop for RTI-MIS online portal from on 28.11.2016at CSIO, New Delhi.
8. Dr Subramaniam S and Dr Khulape SA attended International Conference on Global Perspectives in Virus Disease Management. VIROCON-2016, 8-10 December, 2016, ICAR-IIHR, Bengaluru, India

Personnel

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S.No.	Name of the staff	Designation	Discipline	Joining in the current Post
		Scientific		
1	Dr. Bramhadev Pattnaik	Project Director	Veterinary Microbiology	December 2006
2	Dr. Jajati K Mohapatra	Sr. Scientist	Veterinary Microbiology	March 2012
3	Dr. Saravanan Subramaniam	Sr.Scientist (CAS)	Veterinary Microbiology	January 2007
4	Dr. Manoranjan Rout	Scientist (SS)	Veterinary Pathology	November 2009
5	Dr. Rajeev Ranjan	Scientist (SS)	Veterinary Pathology	May 2010
6	Dr. Jitendra K Biswal	Scientist (SS)	Animal Biochemistry	April 2011
7	Dr. Khulape Sagar Ashok	Scientist	Animal Biotechnology	April 2015
		Technical		
8	Shri Nayan Sanjeev	T-3 (Lab)		October, 2010
9	Shri D.S.Deolia	T-1 (Lab)		January, 2012
10	Shri S.L.Tamta	T-1 (Lab)		April, 2014
		Administration and Accounts		
11	Shri Kumar Rishiraj	AO		December, 2016
12	Shri Harish Chandra Saxena	AAO		November, 2016
13	Shri Tara Kumar	Assistant		April, 2013
14	Shri R.N.Sahoo	UDC		May, 2012
15	Shri Ravi Chaudhary	Junior Stenographer		August, 2014

1. Dr. B B Dash, Sr. Scientist retired in the month of January, 2017
2. Dr G K Sharma and Dr S Mahajan, Scientists were relieved on 05-05-2016 to join IVRI, Bareilly
3. Dr Saravanan S, Scientist promoted from RGP 7000 to RGP 8000
4. Shri Kumar Rishiraj joined as Administrative Officer on 17-12-2016.
5. Shri Harish Chandra Saxena joined as Assistant Administrative Officer on 03-11-2016

Acknowledgements

We express our deep sense of gratitude to Dr T Mohapatra, Secretary DARE & DG, ICAR, Shri S K Singh, AS&FA, DARE, Shri C Roul, AS & Secretary, ICAR, Dr H Rahman/Dr J K Jena, DDG (AS), ICAR, and Dr Ashok Kumar, ADG (AH), ICAR for providing all the necessary financial and infra-structural facilities and providing the guidance. We are thankful for untiring help and support of Principal Scientists (AH) on various matters. We are also thankful to Director, IVRI for necessary support provided at Mukteswar. Untiring effort of a small group of young scientists in achieving new milestones at the institute is praise worthy. We also wish to express our appreciation to the administration, audit, account and technical supporting staffs of the Directorate for their excellent assistance in achieving targets.

Regional workshop on the application of the FAO laboratory mapping tool (LMT) in Bangkok, Thailand during 1-5 August, 2016









Open Session of the Standing Technical Committee of the European Commission for the Control of Foot-and-Mouth Disease meeting at Cascais, Portugal, 25-28 October 2016.

12th OIE/FAO FMD Reference Laboratories Network Annual Meeting at ANSES, Paris, France during 30th November – 2nd December, 2016

"3rd Regional Roadmap Meeting on PCP-FMD for SAARC Member States" held at Colombo, Sri Lanka from 14- 16 December, 2016

Taining programme on "Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR" organized by NAARM, Hyderabad with the help of Centre for Good Governance, Hyderabad during 23-25 February 2017.

Hindi Saptah-2016-17









Inauguration of ICAR-International Centre for Foot and Mouth Disease, Arugul, Bhubaneswar-752050, Odisha by Honourable Minister of Agriculture and Farmers Welfare, Government of India on on 1st April 2017







हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद
Agrisearch with a human touch
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