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Project Directorate on Foot and Mouth Disease
Mukteswar 263 138
Nainital, Uttarakhand, India

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1.0

Project Director's Report

Foot and Mouth Disease (FMD) is a transboundary, economically devastating and highly contagious viral disease of livestock, most importantly cattle and buffalo. The disease also affects goats, sheep, pigs, wild ruminant species and elephants. The causative FMD virus is genetically and antigenically diverse having seven distinct serotypes and many variants within them. Being a single stranded RNA virus, it confirms to the quasispecies nature with emergences and reemergences of different genetic lineages with altered antigenicity within the serotypes, making vaccination based control programme a high cost operation, difficult and time taking to achieve. As per the FAO, the disease is a major threat to food security of the world, and countries having the disease are more prone to food insecurity. Further, FMD free status is an indicator of development, and all developed countries are free from it. The disease is endemic in India and three serotypes of the virus viz; O, A and Asia1 are prevalent. Annual direct loss due to FMD in India has been estimated at Rs.20,000 crores. Many countries in the world are now free from FMD with or without vaccination and presence of the disease in other countries is a major threat to them. Countries having FMD face trade barrier posed by FMD free countries causing heavy economic loss to the livestock industry. Progressive Control Pathway has been developed by FAO for global eradication of this menace. Vaccination based FMD Control Programme is in operation in India which involve regular six monthly vaccinations of all cattle and buffaloes in select areas, regular active surveillance and antibody monitoring in vaccinated population with the objective of creating FMD free zones with subsequent expansion in phases. At present, the disease occurrence, severity of the clinical disease and number of outbreaks have progressively and substantially declined in the control programme areas as a result of last 12 rounds of vaccination with an oil adjuvanted trivalent inactivated vaccine. Short duration of immunity and thermolabile virus structure are major concerns associated with the inactivated vaccine.

During the year, a total of 334 outbreaks were recorded, as against 176 during the previous year 2010-11 (**Table 1.1**). Maximum numbers of outbreaks were reported from Southern region followed by Eastern, Western, North Eastern and Central regions. A total of 959 clinical specimens were tested using sandwich ELISA and multiplex PCR and virus could be diagnosed in 598 samples. More than one clinical sample was collected from same outbreak in many occasions. The details of virus serotype confirmation are shown in **Table 1.2**.

Serotype O was prevalent in all the geographical regions except Western region where, serotype Asia1 dominated the scenario with almost 83% prevalence. Though there is reduction in number of outbreaks in the states of Tamilnadu and Andhra Pradesh, number increased two to four fold in Karnataka and Kerala. Serotype O outbreaks in southern region almost

Table 1.1 Number of confirmed FMD outbreaks in different geographical region of the country during the last six years.

Year	South	North	Central	West	East	North East	Total
2006-07	224	7	23	29	431	64	778
2007-08	445	20	35	31	258	88	877
2008-09	64	18	33	16	66	43	240
2009-10	59	55	20	24	365	75	598
2010-11	51	9	29	18	29	40	176
2011-12	97	20	34	47	71	65	334

doubled compared to last year. Serotype Asia1 appeared in Karnataka for the first time in five years. Majority of the outbreaks owing to serotype Asia1 has been reported from northern Karnataka which shares border with Maharashtra.

Increase in the number of outbreaks has been noted in all the regions of the country. Serotype O caused maximum numbers of outbreaks (69.6%) followed by serotypes Asia1 (25.4%) and A (5%). The outbreaks occurred round the year with maximum occurrence during October to March (**Fig 1.1**)

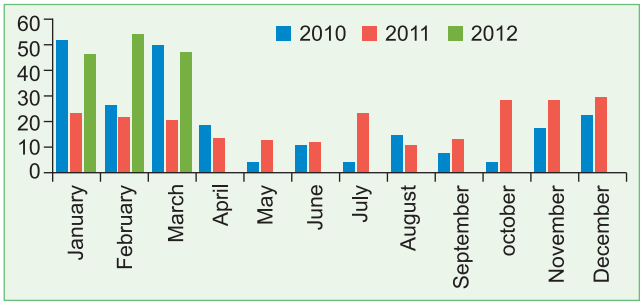


Fig 1.1 Month-wise occurrence of FMD outbreaks

In Northern region, two fold increase in the number of outbreaks was noted and all of these was attributed to serotype O. The region remained completely absent of serotypes A and Asia 1 since last two years. The scenario remained similar to last year in the Central region except for appearance of serotype Asia1. Almost tenfold increase in outbreaks due to serotype Asia 1 has been noted in the Western region. Serotype A appeared in the state of Gujarat for the first time in four years. In Eastern region, two fold increases in serotype O outbreaks and fivefold increase in outbreaks owing to serotype Asia 1 have been observed. The scenario remained similar in North Eastern region as that of previous year except for two fold increase in serotype Asia1 outbreaks (**Table 1.3**).

Table 1.2 Year-wise break-up of outbreaks and FMDV serotypes involved during last six years

Year	Total	O	A	Asia1
2006-07	778	491	83	204
2007-08	877	754	67	56
2008-09	240	196	21	23
2009-10	598	559	24	15
2010-11	176	150	10	16
2011-12	334	233	16	85

Table 1.3 Distribution/incidence of FMD virus serotypes in different geographical regions of the country during 2006-07 to 2011-12

	South			North			Central			West			East			North East			Total Material serotyped
	O	A	Asia1	O	A	Asia1	O	A	Asia1	O	A	Asia1	O	A	Asia1	O	A	Asia1	
2006-07	85 (85%)	7 (7%)	8 (8%)	19 (100%)	0 (0%)	0 (0%)	27 (66%)	0 (0%)	14 (34%)	68 (65%)	8 (8%)	29 (27%)	409 (60%)	97 (14%)	182 (26%)	17 (16%)	6 (6%)	80 (78%)	1207
2007-08	493 (91.8%)	38 (7.1%)	6 (1.1%)	21 (67.7%)	7 (22.5%)	3 (9.7%)	32 (39.5%)	39 (48%)	10 (12.5%)	98 (88.2%)	1 (0.9%)	12 (10.8%)	315 (80.5%)	47 (12%)	29 (7.5%)	83 (70.3%)	4 (3.3%)	31 (26.3%)	1269
2008-09	80 (86%)	13 (14%)	0 (0%)	12 (80%)	0 (0%)	3 (20%)	60 (70.6%)	0 (0%)	24 (29.4%)	18 (69.3%)	2 (7.7%)	6 (23%)	104 (91.2%)	4 (3.5%)	6 (5.3%)	60 (88.2%)	7 (10.3%)	1 (1.53%)	401
2009-10	127 (91.4%)	12 (8.6%)	0 (0%)	37 (66.1%)	13 (23.2%)	6 (10.7%)	42 (93.3%)	3 (6.4%)	0 (0)	40 (57%)	2 (3%)	28 (40%)	619 (99%)	5 (0.8%)	1 (0.16%)	114 (100%)	0 (0%)	0 (0%)	1049
2010-11	98 (98.9%)	1 (1.1%)	0 (0%)	21 (100%)	0 (0%)	0 (0%)	60 (93.7%)	4 (6.3%)	0 (0%)	44 (83%)	0 (0%)	13 (17%)	34 (77%)	0 (0%)	10 (23%)	57 (61.9%)	13 (14.2%)	22 (23.9%)	377
2011-12	154 (92.2%)	1 (0.6%)	12 (7.2%)	59 (100%)	0 (0%)	0 (0%)	58 (84%)	8 (11.6%)	3 (4.4%)	13 (20.6%)	2 (3.2%)	48 (76.2%)	69 (67%)	0 (0%)	34 (33%)	97 (70.8%)	16 (11.8%)	24 (18.2%)	601

Phylogenetic analysis based on VP1 (1D) coding region is routinely carried out to assess genetic variations, inter-strain relationships and track movement of the virus. During the year, phylogenetic analysis of serotype O virus shows that 'Ind2001' strains, which reemerged in late part of the year 2008, out-competed PanAsia lineage in causing outbreaks in the county. The 'Ind2001' lineage was distributed widely in many states including Karnataka, Kerala, Andhra Pradesh and Tamilnadu (Southern region); Uttar Pradesh and Haryana (Northern region); Gujarat and Maharshtra (Western region); Odisha, West Bengal and Bihar (Eastern region); Madhya Pradesh (Central region) and Nagaland and Tripura (North Eastern region). Within the 'Ind2001' lineage, a genetic group with >6% divergence at nt level appeared in Meerut, Uttar Pradesh and traversed a long way to the states of Himachal Pradesh, Uttrakhand and Odisha. PanAsia lineage was restricted to Gujarat and Assam. During the year, a new group of virus named '**Ind2011'** with more than 11% nt. divergence from rest of the lineages emerged in the Southern region. This group of virus first emerged probably in the month of September 2011 in the region and rapidly spread to all the four states (Karnataka, Tamilnadu, Andhra Pradesh and Kerala). Antigenic evaluation of this group relative to vaccine strain revealed morn than 0.45 realationship value. In serotype A, the isolates were found to cluster within the genotype 18, but grouped both in the non-deletion and the Clade 18c of VP3^{59}-deletion lineage. The Asia1 field isolates were of lineage C reiterating the supremacy of this lineage since 2005. This has been a very stable serotype.

Vaccine matching exercise is regularly carried out to evaluate antigenic relationship of field isolates with currently used vaccine strains. This helps in monitoring antigenic variation, if any, occurring in the field, and assessing appropriateness of in-use vaccine strains. Selected virus isolates of all three serotypes were subjected to one-way antigenic relationship analysis (r-value) using Bovine Vaccinate Serum (BVS) against respective vaccine strains. All of them showed good antigenic match (relationship value >0.3) with currently used vaccine strains indicating their appropriateness.

Though currently used vaccine strain for serotype A (IND40/2000) could cover maximum number of isolates, some of the isolates in VP3^{59} -deletion group of genotype 18 showed low r-value in routine vaccine matching exercise. A panel of four candidate strains representing both deletion (IND281/2003, IND360/2007 and IND123/2008) and non-deletion group (IND195/2007) of Genotype 18 were evaluated as alternate vaccine candidates to meet any emergency in future. In the initial screening, antigenic analysis of 19 serotype A field isolates with the alternate vaccine candidates and currently used vaccine strain, IND40/2000, and the previous vaccine strain, IND17/1982, was carried out. The study identified a panel of two candidate vaccine strains from genotype 18, one representing deletion group (IND281/2003) and the other non-deletion group (IND195/2007) as potential alternate vaccine candidates for use in case of necessity/emergency.

LAMP (Loop mediated isothermal amplification) assay targeting 3D gene was developed and evaluated for detection of FMDV in difficult clinical samples. The results demonstrated that all the three FMDV serotypes viz O, A and Asia1 tested could be detected with high sensitivity and specificity. The results of RT-LAMP can be visualized directly by the naked eye by observing colour change and only basic technical skills are required for execution of the assay procedure. The assay is under transfer to the AICRP regional centres and network units.

National FMD Virus Repository was upgraded with 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 62 virus isolates (46 type O, 3 type A and 13 Asia 1) were added to the repository during the year. At present the National FMD virus Repository holds a total of 1774 isolates (O-1148, A-279, C-15 and Asia 1-332).

Under National FMD Serosurveillance, 39,434 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 indicator of FMD virus exposure regardless of vaccination status. The test revealed overall DIVA

positivity of ~ 27% in the country during 2011-12, similar to the previous year.

A major vaccination programme has been initiated by the DADF, Government of India since August 2003-04 for Control of FMD (FMD-CP) covering 54 specified districts (about 30-40 million cattle and buffalo) in the country. This involves 6 monthly vaccinations (trivalent; O, A and Asia1) 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 centres of PDFMD for estimation of level of sero type specific neutralizing antibodies by Liquid Phase Blocking ELISA (LPBE) developed by PDFMD. The Regional Centers, Network Units and Central FMD Laboratory of the Project Directorate participate in this post vaccinal sero-conversion under FMD-CP. All reagent and training to conduct LPB ELISA are provided by the institute. The test was compared with SNT, and it is recommended that LPB ELISA titer (in serum) of $\log_{10}$ 1.8 indicates protection against FMD. Due to initial success, additional 167 districts (another 80-90 million cattle and buffalo) have been included under the programme in 2010-11. Currently, this programme includes 221 districts of the country covering 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 and 16 districts in Uttar Pradesh (Fig 4), and targeting ~120 million cattle and buffalo. During 2011-12, a total of 47,510 pre and post vaccinated serum samples were tested and of which, 24,970 serum samples were from first phase FMDCP districts representing XI, X, XI and XII phases of vaccinations. Remaining 22,540 serum samples were from expanded FMD CP districts representing Phases I and II of vaccinations. After phase XI vaccination, 76.88, 71.27 and 60.77 percent of animals tested were having protective antibody level ($\log_{10}$ 1.8 and above) against serotypes O, A and Asia1, respectively in post-vac serum samples. The herd immunity has progressively increased with minor aberrations that speak for positive impact of vaccination for last 6-7 years. There has been gradual decline in occurrence of the disease in vaccinated areas. After phase I vaccination under expanded FMDCP, 70.8, 59.1 and 49.73 percent of animals tested were having protective antibody level against serotypes O, A and Asia-1, respectively in post-vac serum samples.

Regular training and refresher courses for the scientific staff of Regional Centers and Network units were conducted on use/application of virus typing ELISA, LPB-ELISA and DIVA ELISA. Overall performance of the regional centers and network units were monitored periodically and any technical difficulties faced by them were removed instantly through electronic guidance. Sufficient fund was provided to all the centers and network units of the AICRP to carry out the technical programmes. Requirement of diagnostics kits in the Government sector and vaccine industry was met by the institute. Training programmes were also organized on LPBE, Sandwich ELISA and DIVA for SARRC member countries as Regional Leading Diagnostic Laboratory (RLDL) for FMD in South Asia.

I am happy to share that PDFMD is now 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 a member of GFRA (Global FMD Research Alliance). International Center for FMD will be established and commissioned by 2014-15. Creation of this international laboratory with state-of-the-art features of bio-safety and bio-containment (BSL 3+) will facilitate Global participation and control of the disease in the SAARC region. I thank all my fellow scientist colleagues, administrative, accounts and laboratory staff of the institute for their sincere efforts and contribution in to accomplishing the tasks assigned to the Institute. We are indebted to the scientific and administrative support of Hon'ble Director General, ICAR and Dy Director General (AS), as well as Asst Director General (AH) and Principal Scientist (AH).

–B. PATTNAIK

2.0 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 outbreaks, 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 outbreaks, 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 outbreaks, 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.

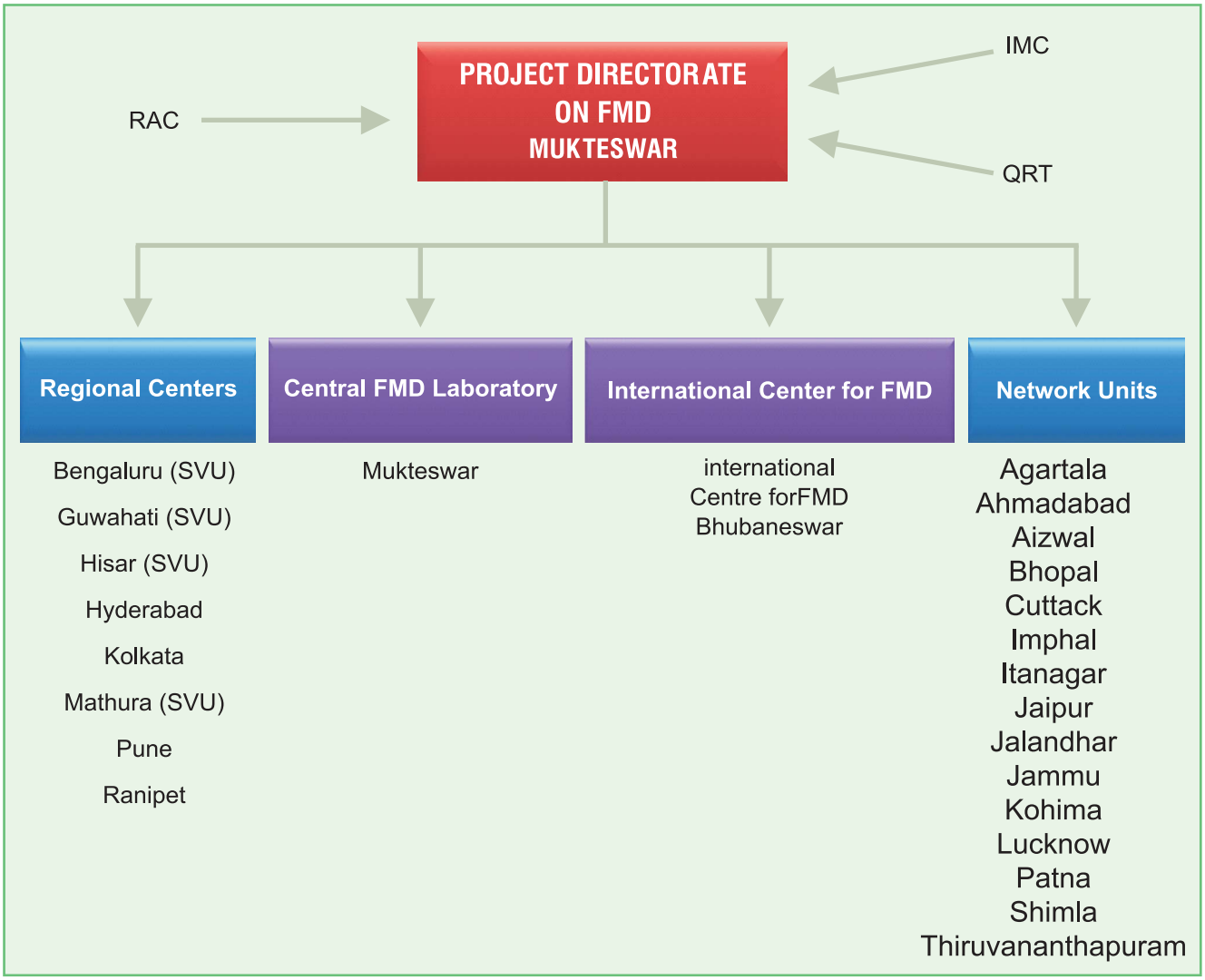
Technical Programme

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 (sandwich ELISA and mPCR kit), sero-monitoring (LPB-ELISA) and serosurveillance (NSP-DIVA ELISA)
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.

3.0

Organizational Setup

The Project Directorate on 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 expanded progressively and several milestones were achieved to reach the current status of a Project Directorate in 2001 with 23 Regional Centers and Network Units covering all the major regions of the country. The Project 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.



4.0

Staff Position

Scientific Staffs

S.No.	Name of the scientist	Designation	Discipline	Joining in the Current Post
1	Dr. Bramhadev Pattnaik	Project Director	Veterinary Microbiology	December 2006
2	Dr. Aniket Sanyal	Pr. Scientist	Veterinary Microbiology	April 2009
3	Dr. Bana B. Dash	Sr. Scientist	Veterinary Microbiology	August 2009
4	Dr. Jajati K. Mohapatra	Sr. Scientist	Veterinary Microbiology	Joined March 2012
5	Dr. Saravanan Subramaniam	Scientist	Veterinary Microbiology	May 2007
6	Dr. Sachin S Pawar	Scientist	Animal Biotechnology	May 2008(On study leave)
7	Dr. Muniswamy Kankeyan	Scientist	Animal Biotechnology	June 2008
8	Dr. Gaurav K. Sharma	Scientist	Veterinary Microbiology	December 2009
9	Dr. Manoranjan Rout	Scientist	Veterinary Pathology	March 2010
11	Dr. Rajeev Ranjan	Scientist	Veterinary Pathology	September 2010
12	Dr. Jitendra K. Biswal	Scientist	Animal Biotechnology	September 2011

Administrative, Technical and Supporting staff

S.No.	Name of the staff	Designation	Joining in Current Post	Month of Leaving
1	Shri D.N. Joshi	AAO	January 2009	Continuing
2	Shri Raja Ram	AF & AO	February 2012	Continuing
3	Shri A.K.D. Bhatt	T-3 (Stockman)	April 1999	Continuing
4	Shri Nayan Sanjeev	T-3 (Lab)	October 2010	Continuing
5	Shri D.S. Deolia	T-1 (Lab)	January 2012	Continuing
6	Shri J.P. Bhan	S. S. Gr. IV	February 2008	Continuing

5.0

Epidemiology Report

To assess the regional prevalence of FMDV serotypes, country is divided in to five geographical regions namely; Eastern (States of Bihar, Orissa, West Bengal and Jharkhand), Southern (States of Tamilnadu, Kerala, Karnataka and Andhra Pradesh), North Eastern (States of Assam, Manipur, Meghalaya, Mizoram, Arunachal Pradesh, Sikkim and Tripura), Northern (States of Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Jammu& Kashmir and Uttarakhand), Western (States of Rajasthan, Gujarat and Maharashtra) and Central (Madhya Pradesh and Chhattisgarh).District wise serotype distribution of FMDV is presented under each heading [**Red**: serotype O, **Blue**: serotype A, **Green**: serotype Asia1, **Yellow**: serotype O and A, **Violet**: serotype O and Asia1 and **Sky-blue**: serotype A and Asia1]

Table 5.1 FMD cases/outbreaks recorded and diagnosed during 2011-12 and virus serotype(s) involved

States	Reporting Centre/Unit	No. of FMD cases/ outbreaks	No. of Samples tested	Serotyping Results		
				O	A	Asia1
Southern Region						
Tamil Nadu	Ranipet	07	47	07(26)	-	-
Andhra Pradesh	Hyderabad	03	19	03(07)	-	-
Karnataka	Bangalore	52	135	43(71)	1(1)	08(11)
Kerala	Thiruvananthapuram	35	121	34(50)	-	1(1)
Total		**97**	**322**	**87(154)**	**1(1)**	**09(12)**
Northern Region						
Jammu & Kashmir	Jammu	05	15	05(08)	-	-
Haryana	Hisar	04	15	04(13)	-	-
Himachal Pradesh	Shimla	03	14	03(11)	-	-
Punjab	Jalandhar	-	03	-	-	-
Uttar Pradesh	Mathura	04	04	04(04)	-	-
	CADRAD, PDFMD	05*	38	05(22)	-	-
Uttarakhand	CADRAD	01	01	01(01)	-	-
Total		**20**	**90**	**20(59)**	**-**	**-**
Central Region						
Madhya Pradesh	Bhopal	27	85	24(57)	03(05)	-
Chhattisgarh	Pune	07	28	01(01)	03(03)	03(03)
Total		**34**	**113**	**25(58)**	**06(08)**	**03(03)**
Western Region						
Gujarat	Ahmedabad	05	26	01(07)	01(02)	03(12)
Maharashtra	Pune	41	108	06(06)	-	35(35)
Goa	Pune	01	02	-	-	01(01)
Total		**47**	**136**	**07(13)**	**01(02)**	**39(48)**

States	Reporting Centre/Unit	No. of FMD cases/ outbreaks	No. of Samples tested	Serotyping Results		
				O	A	Asia1
Eastern Region						
Odisha	Cuttack	14	19	14(05) †	-	-
Bihar	Patna	11	25	11(18)	-	-
West Bengal	Kolkata	46	84	27(46)	-	19(34)
Total		**71**	**128**	**52(69)**	**-**	**19(34)**
North Eastern Region						
Assam	Guwahati	42	65	21(28) †	06(11)	15(24)
Meghalaya	Guwahati	01	-	01(02)	-	-
Arunachal	Itanagar	02	40	02(28)	-	-
Nagaland	Kohima	12	28	10(15)	02(05)	-
Mizoram	Aizwal	01	03	01(03)	-	-
Manipur	Imphal	01	04	01(04)	-	-
Tripura	Agartala	06	31	06(17)	-	-
Total		**65**	**170**	**42(97)**	**08(16)**	**15(24)**
Grand Total		**334**	**959**	**233(450)**	**16(27)**	**85(121)**

* Outbreaks in Etah and Etawah also reported by Mathura center

† 10 outbreaks in Odisha, 5 outbreaks in Assam and one in Meghalaya were diagnosed in retrospect and found caused by serotype O
Number of samples collected from FMD suspected outbreaks and diagnosed is given in parenthesis
More than one clinical material was collected from many cases/outbreaks of FMD

5.1 Southern region

Tamilnadu: During the year under report, 07 FMD cases/outbreaks were recorded in the state involving mainly cattle (443) and buffaloes (47). Highest number of cases (3) were reported during the month of December followed by two in November and one each in January and March. Maximum number of cases were reported from Dindugal district (2) followed by one each in Tirupur, Namakkal, Kanchepuram, Thanjavur and Erode districts. FMDV serotype O was responsible for all the 7 outbreaks/cases. Last occurrence of serotypes A and Asia1 was during 2007-08. The state remained FMD free for two years (2008-09 and 2009-10)

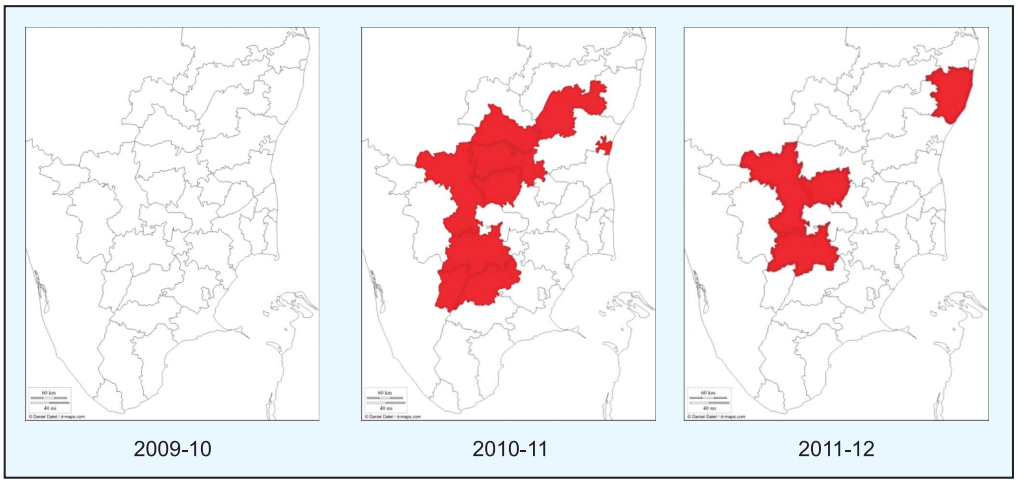


Fig 5.1 Districtwise FMDV serotype distribution in Tamilnadu during 2009-10 to 2011-12 [**Red**: serotype O]

Andhra Pradesh: A total of 03 outbreaks/cases of FMD were recorded in two districts, Kadappa (2) and Kurnool (1) of the state. The disease was recorded in the months of September (1) and November (2), and caused by serotype O. The cases mainly involved Buffaloes (47) and Cattle (35). Serotype A which was present during 2009-10 and 2010-11 is absent in the current year. The state is free of serotype Asia1 since 2007-08.

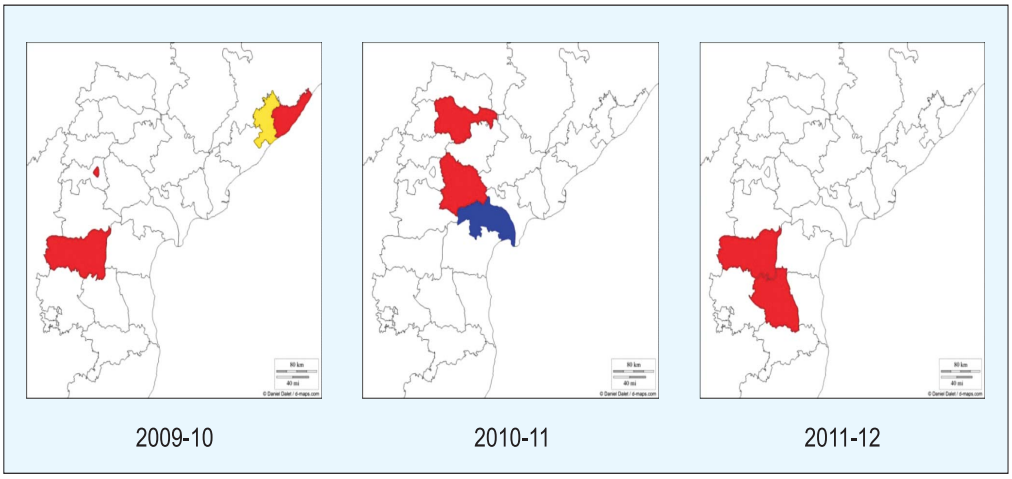


Fig 5.2 Districtwise FMDV serotype distribution in Andhra Pradesh during 2009-10 to 2011-12 [**Red**: serotype O, **Blue**: serotype A and **Yellow**: serotype O and A]

Karnataka: During the year, 52 outbreaks/cases were reported in the state. Serotype O caused maximum number of cases (43) followed by serotypes Asia 1(8) and A (1). Highest number of cases were reported from Chikkaballapur (20) followed by Ramanagara (8), Kolar (6), Belgaum (5), Bangalore North (4), Bagalkot (2) and Tumkur (2) and one each in Bangalore urban, Bangalore rural, Mandya, Mysore and Davangere. The disease was recorded almost throughout the year *viz*; January (15), February (11), October (8), March (4), December (4), November (3), April (2), July (2) and September (2). The disease affected cattle (951), buffaloes (41), sheep (123), and Pigs (4). For the first time in last five years (since 2006-07), serotype Asia1 appeared in the state. Last case due to serotype A was recorded in 2008-09.

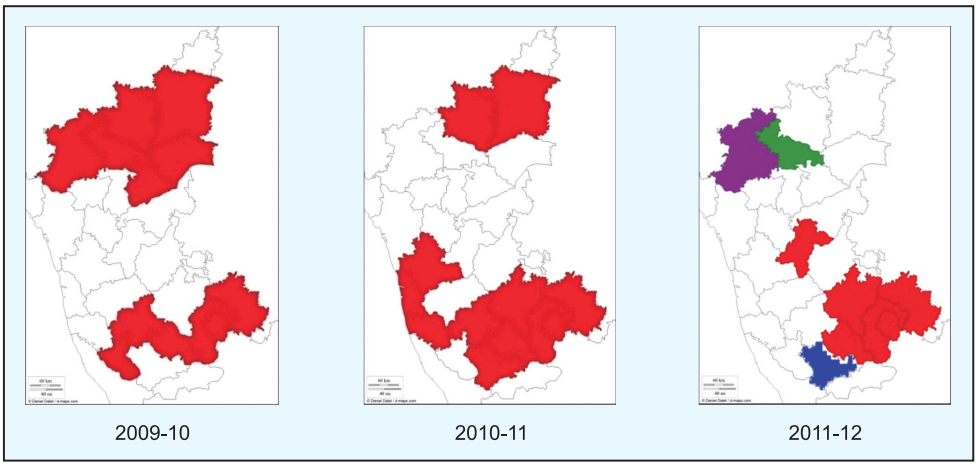


Fig 5.3 Districtwise FMDV serotype distribution in Karnataka during 2009-10 to 2011-12 [**Red**: serotype O, **Blue**: serotype A, **Green**: serotype Asia1 and **Violet**: serotype O and Asia1]

Kerala: A total of 35 outbreaks/cases were recorded in Kollam (6), Trivandrum (5), Alappuzha (5), Palakkad (4), Kozhikode (3), Ernakulam (5), Pathanamithitta (2), Kottayam (1), Wayanad (1), Kannur (1) and Malappuram (1) districts. Disease was recorded in the months of January (7), July (4), October (4), December (4), March (3), May (3), August (3), September (2) and November (1). Serotype O was identified in 34 cases while one was caused by serotype Asia1. The disease mainly affected cattle (448) and a small number of buffaloes (9) and Goats (2). Previous incidence of serotypes Asia1 and serotype A was recorded in 2007-08 and 2009-10, respectively.

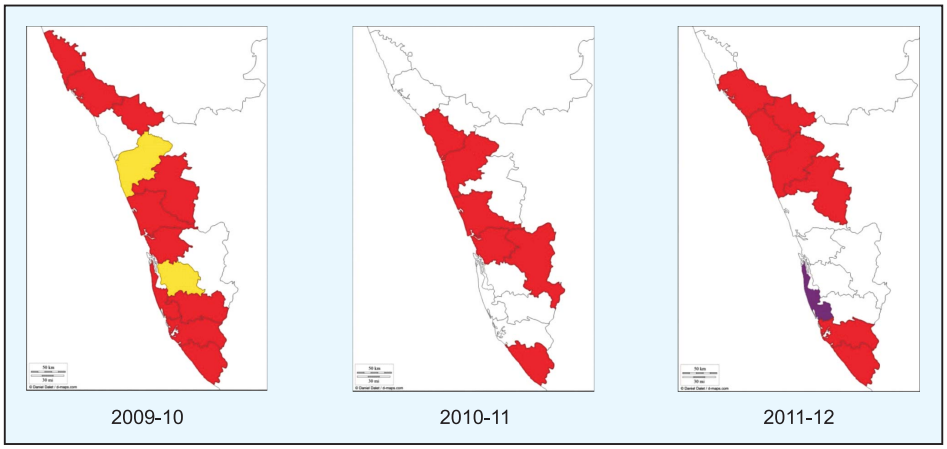


Fig 5.4 Districtwise FMDV serotype distribution in Kerala during 2009-10 to 2011-12 [**Red**: serotype O, **Yellow**: serotype O and A, and **Violet**: serotype O and Asia1]

5.2 Northern Region

Jammu and Kashmir: Five outbreaks/cases owing to serotype O was recorded in the state. Four of them were reported form Jammu district and one in Udhampur district. The disease was recorded in the months of February (3) and March (2) affecting only cattle (117). Serotypes A and Asia1 have not been recorded in the state since last five years (2006-2011).

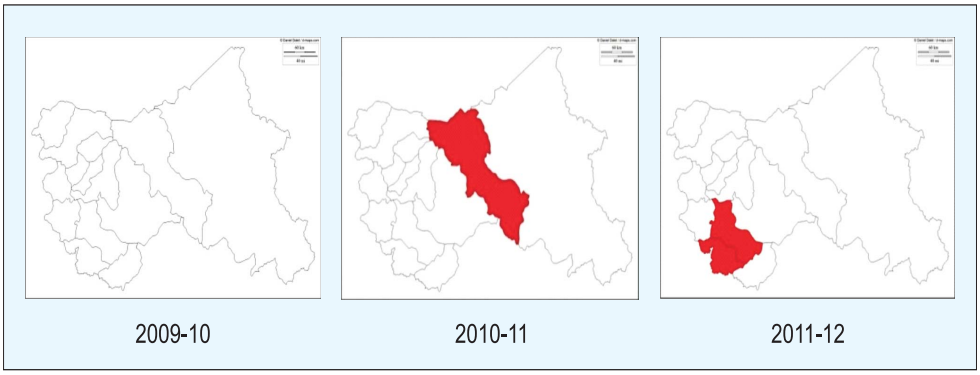


Fig 5.5 Districtwise FMDV serotype distribution in Jammu and Kashmir during 2009-10 to 2011-12 [**Red**: serotype O]

Punjab: During the period under report, 3 FMD suspected cases involving cattle (31) and buffaloes (12) were recorded. These occurred in the month of February in the districts of Hoshiapur and Mohali. But serotype could not be determined as clinical materials could not be collected. Last outbreak due to serotype A was recorded in 2009-10 and the state remained completely absent from serotype Asia1 since last five years.

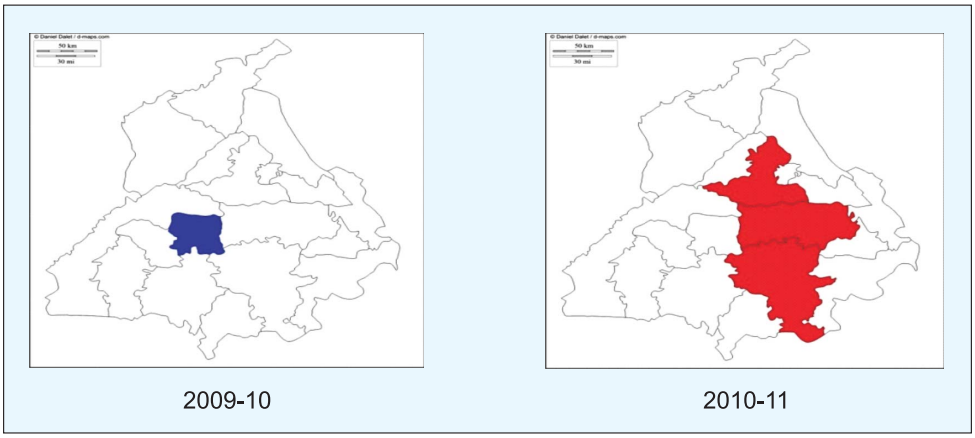


Fig 5.6 Districtwise FMDV serotype distribution in Punjab during 2009-10 to 2010-11 [**Red**: serotype O and **Blue**: serotype A]

Haryana: Four FMD outbreaks/cases were recorded in the state. Three incidences were recorded in the month of March in the districts Rohtak, Bhiwani and Jhajjar. In Jhajjar, the disease was also recorded in February. The outbreaks were caused by serotype O affecting Cattle (42), Buffaloes (115) and Pigs (2). Last incidence of serotypes A and Asia1 was in 2009-10 and 2008-09, respectively. Movement of a few animals from

Beri village (Jhajjar) to Chandpur (Jhajjar) and sudana villages (Rohtak) initiated the outbreak. Seromonitoring studies conducted revealed that vaccination in these villages were not proper as animals were not having protective antibody levels and hence remained susceptible to the disease.

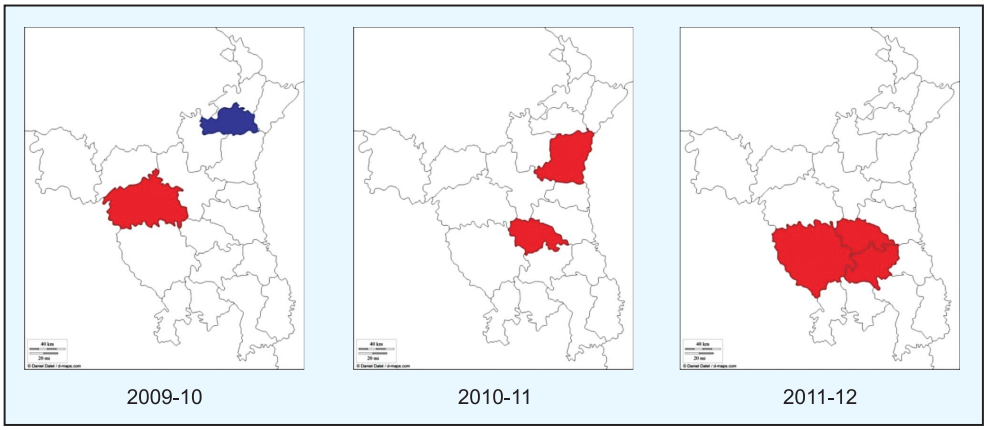


Fig 5.7 Districtwise FMDV serotype distribution in Haryana during 2009-10 to 2010-11 [**Red**: serotype O and **Blue**: serotype A]

Uttar Pradesh: During the period under report, a total of seven outbreaks/cases were recorded in the state. The disease mainly affected cattle and buffaloes and was recorded in the months of March (5), May (1) and January (1). Serotype O was responsible for all the seven outbreaks which occurred in the districts of Mathura (2), Meerut (2), Muradnagar (1), Etah (1) and Etawah (1). Since last two years (2010-11 and 2011-12), all the outbreaks in the state are caused by serotype O.

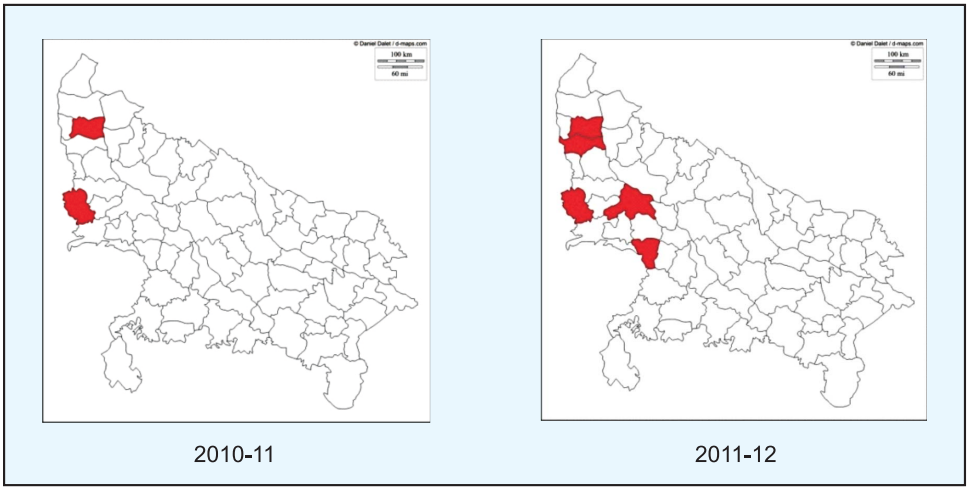


Fig 5.8 Districtwise FMDV serotype distribution in Uttar Pradesh during 2010-11 to 2011-12 [**Red**: serotype O]

Himachal Pradesh: Three outbreaks/cases due to serotype O was recorded in the state in the month of February 2012. The outbreaks were recorded in Shimla, Solan and Sirmour districts. The state remained completely absent from FMD during 2007-09. Single case of FMD owing to serotype O was recorded in the state each in 2009-10 and 2010-11.

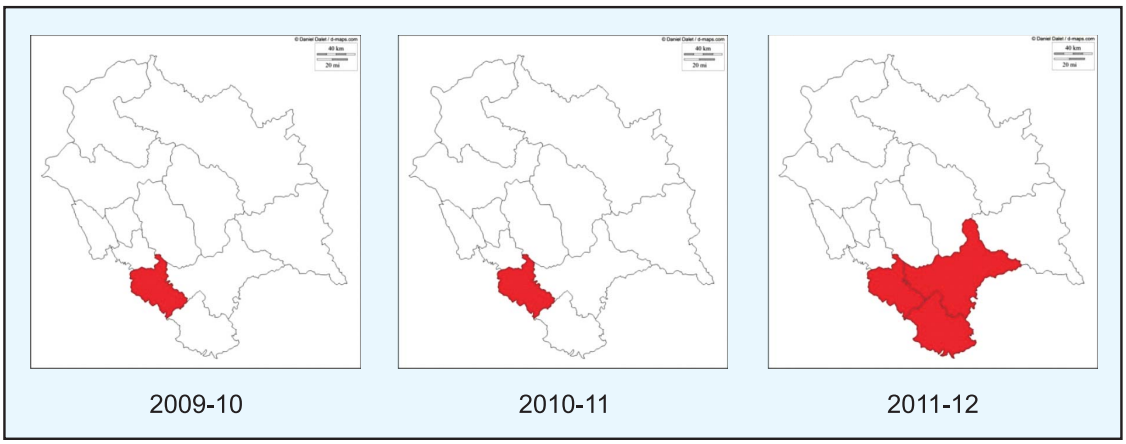


Fig 5.9 Districtwise FMDV serotype distribution in Himachal Pradesh during 2009-10 to 2011-12 [**Red**: serotype O]

Uttarakhand: One FMD outbreak was recorded in Haridwar district in the month of March 2012. Serotype O was diagnosed as the cause of the outbreak in the state which remained FMD free during last year. The disease due to serotypes O and A was recorded in the year 2009-10 and the state remained FMD free in 2010-11.

Fig 5.10 Districtwise FMDV serotype distribution in Uttarakhand during 2009-10 to 2011-12 [**Red**: serotype O and **Blue**: serotype A]

5.3 Western region

Gujarat: During the year, 5 outbreaks/cases of FMD were recorded. Two were recorded in the month of February followed by one each in July, December and April. All the three serotypes are prevalent in the state. Serotype Asia1 caused three outbreaks, whereas O and A was responsible for one outbreak each. Outbreaks due to serotype O and A was recorded in Ahmadabad district and incidence of serotype Asia1 was recorded in Junagadh and Kheda districts. Serotype A appeared after almost four years since its previous occurrence in 2006-07. Serotype Asia1 has been regularly prevalent in the state.

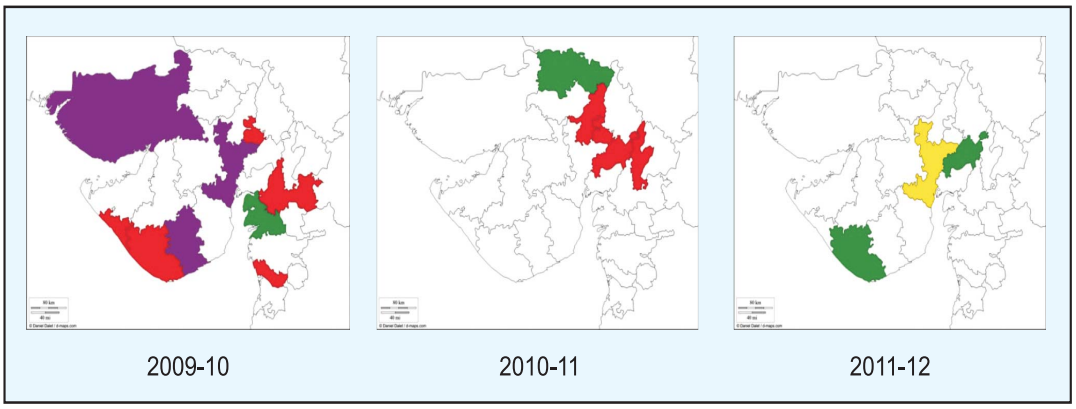


Fig 5.11 Districtwise FMDV serotype distribution in Gujarat during 2009-10 to 2011-12 [**Red**: serotype O, **Green**: serotype Asia1, **Yellow**: serotype O and A, and **Violet**: serotype O and Asia1]

Maharashtra: During the year, 41 outbreaks/cases of FMD were recorded in the state. Maximum number of cases were recorded in the month of January (12) followed by December (9), February (9), March (8) and November (3). Serotype Asia1 dominated the scenario with 35 outbreaks followed by serotype O in causing the remaining 6 outbreaks. The disease was recorded in the districts of Ahmadnagar (14), Pune (8), Satara (4), Kolhapur (4), Osmanabad (04), Sangali (3), Latur (1), Mumbai (1), Nasik (1) and Sindhudurg (1). Disease due to serotype Asia1 has been continuously recorded since 2006-07 and this year the state recorded highest numbers of cases/outbreaks caused by serotype Asia1.

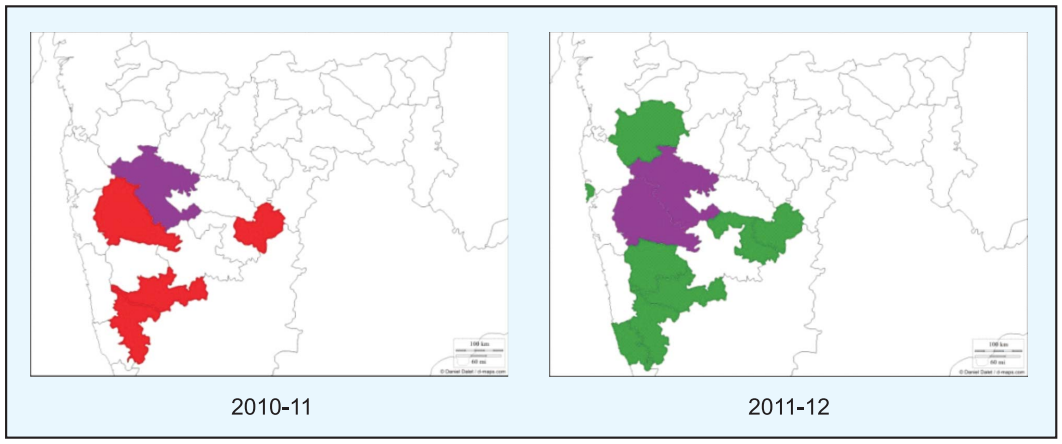


Fig 5.12 Districtwise FMDV serotype distribution in Maharashtra during 2010-11 to 2011-12 [**Red**: serotype O, **Green**: serotype Asia1 and **Violet**: serotype O and Asia1]

Goa: One outbreak due to serotype Asia1 was recorded in the month of February in Dialgon district

5.4 Eastern Region

West Bengal: Forty-six FMD outbreaks/cases were recorded during the period in the state which involved mainly cattle (758) and also goats (6). Highest number of FMD outbreaks were in Purulia (11) followed by eight in Birbhum district. The other districts viz; 24 Parganna, Howrah, Bankura and Jalpaiguri recorded four outbreaks each. The rest of the outbreaks were recorded in Nadia (3), Darjeeling (2), Hooghly (2), Murshidabad (2), Malda (1) and Medinapur (1). Outbreaks occurred alomost throughout the year in the

months of January (9), February (8), March (8), May (6), April (4), August (3), July (2), September (2), November (2), June (1) and December (1). Prevalence of FMD virus serotype O was maximum that caused 27 outbreaks. FMDV serotype Asia 1 was responsible 19 outbreaks. Last incidence of serotype A was recorded in 2009-10. Outbreaks due to serotypes O and Asia 1 have been occurring regularly since the last five years.

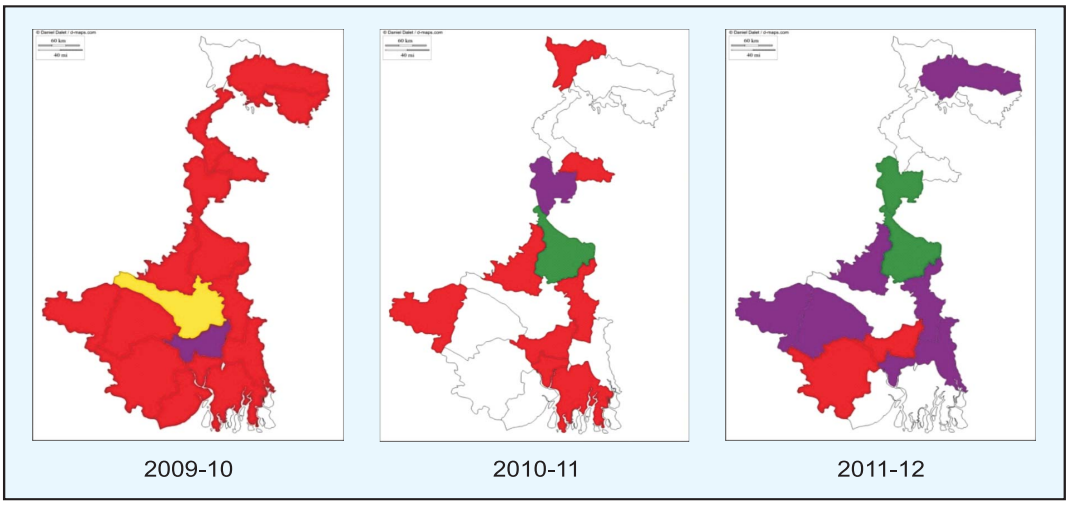


Fig 5.13 Districtwise FMDV serotype distribution in West Bengal during 2009-10 to 2011-12 [**Red**: serotype O, **Green**: serotype Asia1, **Yellow**: serotype O and A, and **Violet**: serotype O and Asia1]

Odisha: Fourteen outbreaks/cases owing to FMDV serotype O was recorded in the state in the months of February (4), November (3), March (2), October (2), July (2) and August (1). Maximum outbreaks were recorded in Cuttack (5) followed by Ganjam (2), and one each in Nabrangpur, Koraput, Sambalpur, Deogarh, Angul, Sundergarh and Dhenkanal. Clinical materials could only be collected from four outbreaks and rest of the outbreaks were diagnosed retrospectively using serum samples from cattle and buffalo. All the outbreaks were caused by serotype O. Serotype Asia1 has been absent in the state since last five years, and last occurrence of serotype A was in 2009-10.

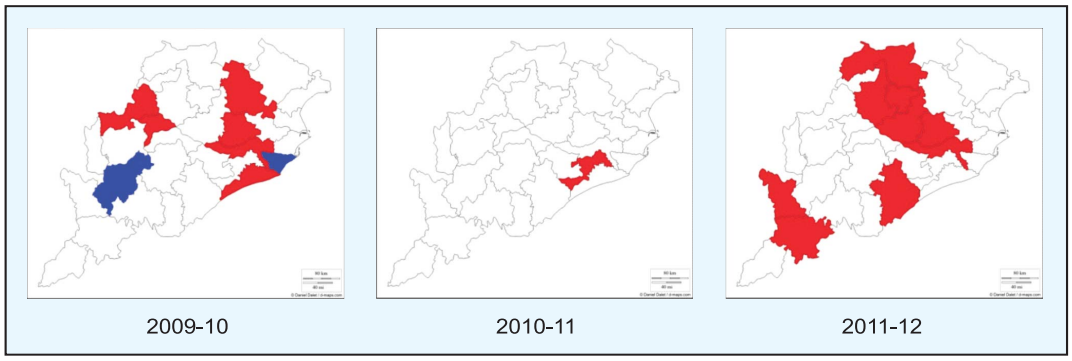


Fig 5.14 Districtwise FMDV serotype distribution in Odisha during 2009-10 to 2011-12 [**Red**: serotype O and **Blue**: serotype A]

Bihar: During the period under report, 11 outbreaks/cases of FMD due to serotype O were recorded in the state. The disease occured in the months of November (4), December (3), July (2), June (1) and March (1). Highest number of outbreaks were recorded in Chhapra district (3) followed by 2 each in

Patna and Bhojpur, and one each in Arwal, Bhabhua and Jehanabad districts. Both Buffalo (4492) and cattle (3842) were affected.

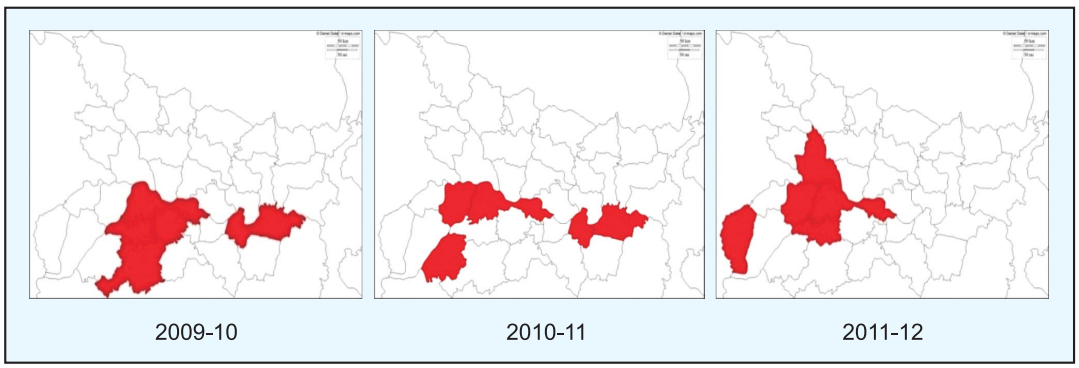


Fig 5.15 Districtwise FMDV serotype distribution in Bihar during 2009-10 to 2011-12 [**Red**: serotype O]

5.5 North Eastern Region

Assam: Forty-two outbreaks/cases of FMD were recorded in Assam. Outbreaks were widespread and occurred in fourteen districts of the state including Kamrup (9), Golaghat (7), Sivasagar (6), Jorhat (4), Kokrajhar (3), Nagaon (2), Morigaon (2), Udalguri(2), Tinsukia (2), Dhubri (1), Chirang (1), Nalbari (1), Dhemaji (1) and Cachar (1). Besides cross bred and local cattle (7070), buffaloes (50) were also affected. Highest number of outbreaks was in the month of July (9) followed by six each in October, November and June, two each in May, August, September, and March, and one in February. All the three serotypes viz; O (21), A (6) and Asia1 (15) were recorded during the period in Assam. Serotype Asia1 and A appeared in the state in 2010-11 after a gap of two years, and also continued during 2011-12.

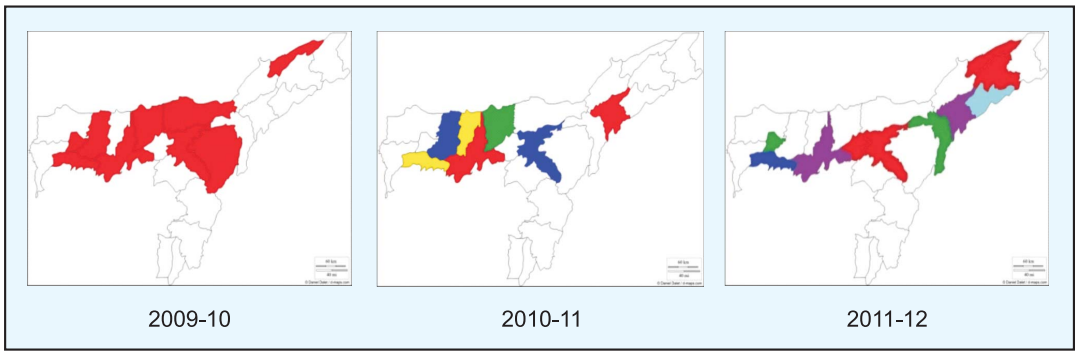


Fig 5.16 Districtwise FMDV serotype distribution in Assam during 2009-10 to 2011-12 [**Red**: serotype O, **Blue**: serotype A, **Green**: serotype Asia1, **Yellow**: serotype O and A, **Violet**: serotype O and Asia1 and **Sky-blue**: serotype A and Asia1]

Meghalaya: One sporadic incidence was recorded in Rihboi district involving cattle. The disease which occurred in the month of February was diagnosed in retrospect and was caused by serotype O. Serotype Asia1 was recorded in 2010-11 and serotype A was detected in 2006-07.

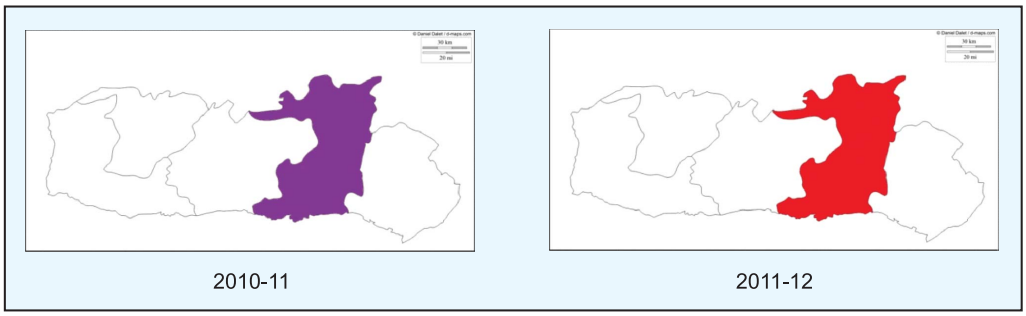


Fig 5.17 Districtwise FMDV serotype distribution in Meghalaya during 2010-11 to 2011-12 [**Red**: serotype O and **Violet**: serotype O and Asia1]

Arunachal Pradesh: Two outbreaks/cases of FMD were confirmed in the state involving cattle (95) and mithun (28). The outbreaks were recorded in Papum Pare and Lower Subansiri districts in the months of April and June. Both the outbreaks were caused by serotype O. Last outbreak owing to serotype Asia1 and A was recorded in 2010-11 and 2008-09, respectively.

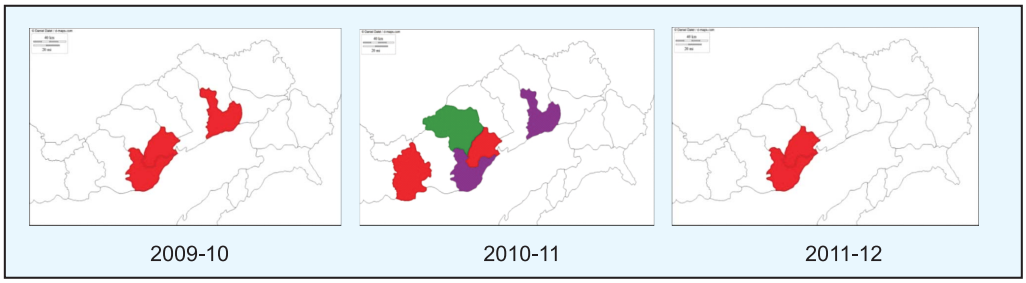


Fig 5.18 Districtwise FMDV serotype distribution in Arunachal Pradesh during 2009-10 to 2011-12 [**Red**: serotype O, **Green**: serotype Asia1 and Violet: serotype O and Asia1]

Mizoram: During the period under report one incidence of FMD was recorded in the district Kolasip affecting only cattle. It was recorded in the month of July and was caused by serotype O. Serotype Asia 1 has not been detected in the state since last five years, and last incidence owing to serotype A was recorded in 2008-09.

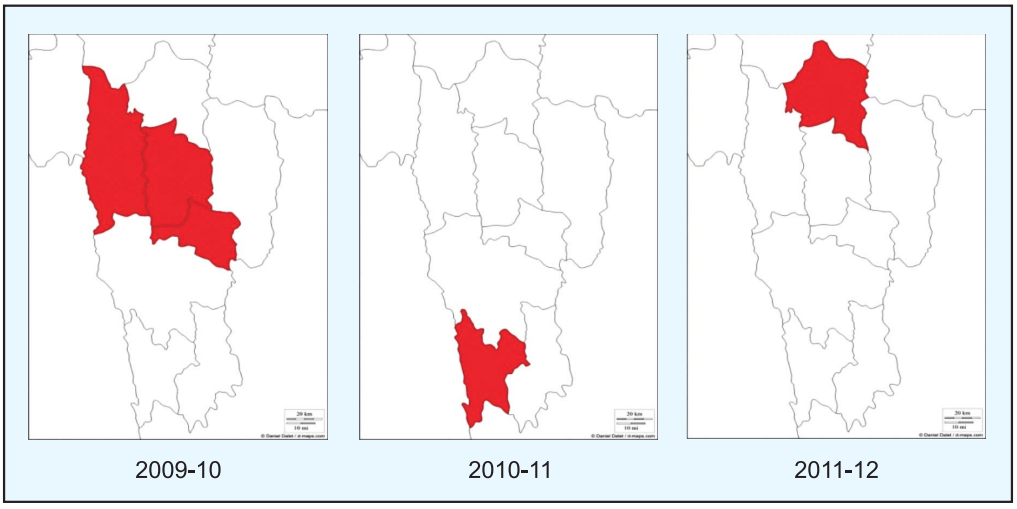


Fig 5.19 Districtwise FMDV serotype distribution in Mizoram during 2009-10 to 2011-12 [**Red**: serotype O]

Manipur: During the year, 1 outbreak/case of FMD in the district Thoubal was recorded. It was caused by serotype O virus. The disease occurred during March and affected only Cattle. Serotype A and Asia has not been detected in the state since last five years.

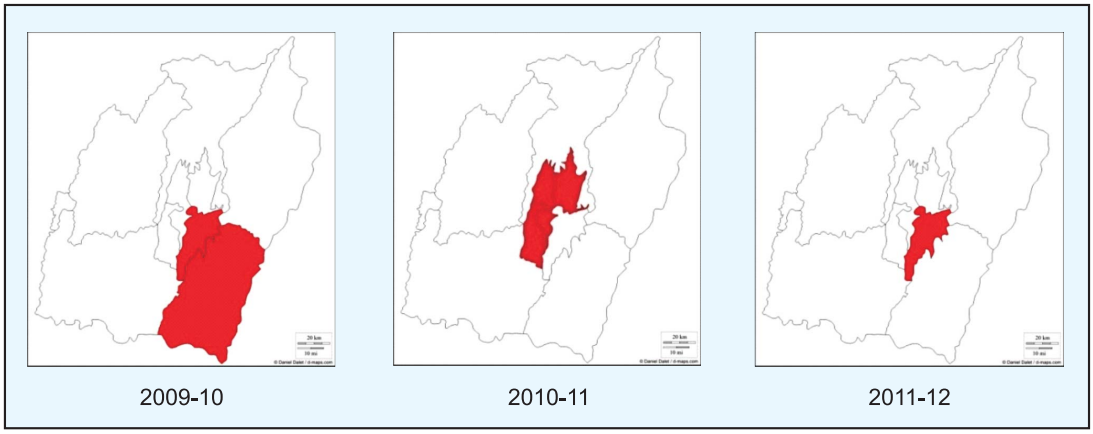


Fig 5.20 Districtwise FMDV serotype distribution in Manipur during 2009-10 to 2011-12
[**Red**: serotype O]

Nagaland: Twelve outbreaks/cases were recorded in the state and of which 10 outbreaks/cases were attributed to serotype O and two were caused by serotype A. Outbreaks were recorded in the districts of Kohima (5), Zunheboto (2), Phek (1), Dimapur (2), Paren (1) and Longleng (1). The disease occurred during September (3), August (2), April (1), May (1), June (1), July (1), October (1) and November (1). Serotype A was detected in the state for the first time in last five years.

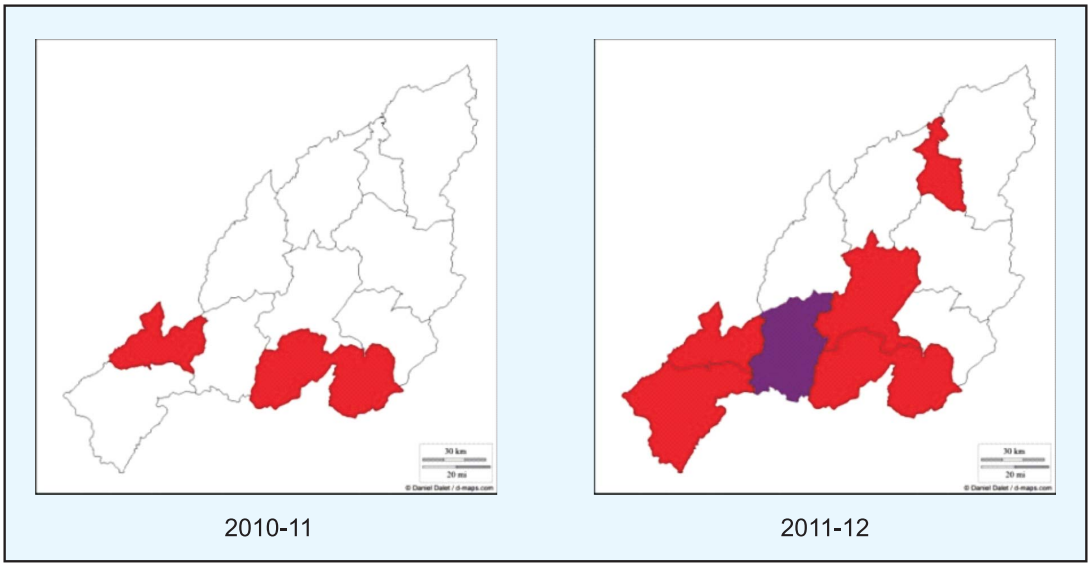


Fig 5.21 Districtwise FMDV serotype distribution in Nagaland during 2010-11 to 2011-12
[**Red**: serotype O and **Violet**: serotype O and Asia1]

Tripura: During the period under report, 6 outbreaks/cases of FMD due to serotype O were recorded in the state. Disease was recorded in the months of February (4), June (2) and November (1). Five outbreaks were recorded in West Tripura and one in South Tripura that involved cattle.

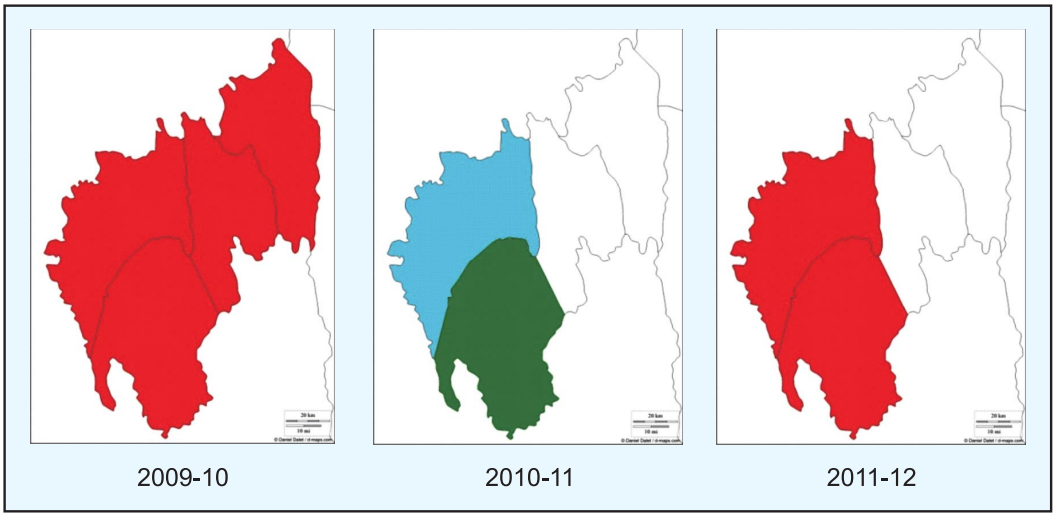


Fig 5.22 Districtwise FMDV serotype distribution in Tripura during 2009-10 to 2011-12
[**Red**: serotype O, **Green**: serotype Asia1, and **Sky-blue**: serotype A and Asia1]

5.6 Central Region

Madhya Pradesh: Twenty-seven FMD outbreaks/ cases were recorded in nine districts of Madhya Pradesh viz; Dhar (6), Seoni (5), Betul (3), Harda (3), Mandla (3) and Sager (3), Ujjain (2), Bhopal (1) and Satna (1). Twenty six (26) outbreaks involved both cattle and buffaloes, and one involved only in cattle. No disease was reported in goat, sheep and pigs. Maximum number of outbreaks were reported in the month of December (9) followed by February and March (6), October (4), and January (2). Twenty four outbreaks were caused by serotype O virus and three were due to serotype A virus.

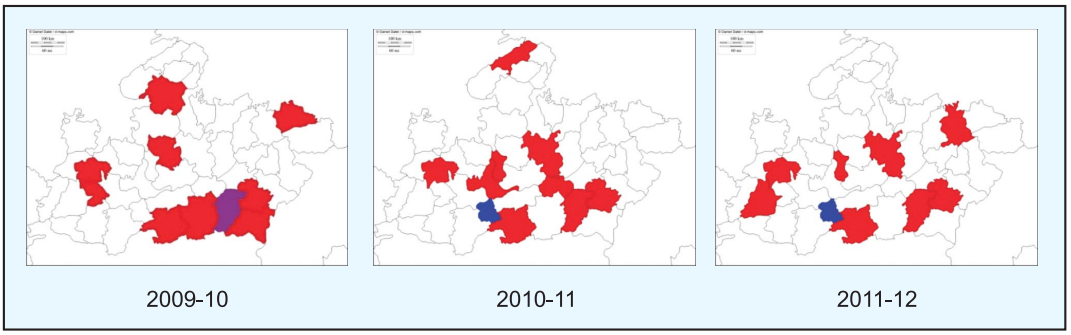


Fig 5.23 Districtwise FMDV serotype distribution in Madhya Pradesh during 2009-10 to 2011-12
[**Red**: serotype O, **Blue**: serotype A, and **Violet**: serotype O and Asia1]

Chhattisgarh: Seven FMD outbreaks were recorded in the state. The serotypes O, A and Asia1 caused one, three and three outbreaks, respectively. Outbreaks occured in the months of April (5) and November (2). Outbreaks were recorded in Dhamtari (3), Raigarh (1), Ambikapur (1), Bilaspur (1) and Kanker (1). While all the three serotypes were recorded in Dhamtari district, Bilaspur and Kanker recorded outbreaks due to serotype A, and Asia1 was detected in Raigarh and Ambikapur districts.

6.0

Virology and Molecular Epidemiology

6.1 Processing of field samples, virus isolation and serotyping

A total of 567 clinical materials from FMD suspected outbreaks/cases were received through Regional Centres and Network Units of the project for confirmatory diagnosis and further characterization at the Central FMD laboratory, Mukteswar. The scientists of Central FMD Laboratory also attended and investigated important outbreaks. Maximum number of clinical samples were received from Karnataka followed Kerala and Tamilnadu. The tissue samples were processed using chloroform and made in to 10% suspension in PBS. The processed materials were subjected to sandwich ELISA, and ELISA negative samples were tested by multiplex PCR for virus diagnosis. Virus isolation was done in BHK-21 cells and RNA transfection was also used for virus revival. FMDV serotype O virus found in maximum number of outbreak samples (265), and serotypes A and Asia 1 virus were detected in 4 and 40, respectively. Virus isolation could be made in 62 samples.

6.2 Genetic and antigenic characterization of FMD Virus field isolates

Molecular epidemiological analysis based on highly immunogenic capsid protein, VP1 is very essential for understanding and monitoring virus evolution, tracking virus movement and reservoirs. VP1 coding region of FMDV field isolates were amplified either directly from clinical materials or cell culture passaged virus. Phylogenetic analysis was carried out using MEGA software by applying either maximum likelihood or neighbour joining method. Though a good inactivated FMD vaccine is available, periodic emergence of antigenically divergent strains complicates disease control strategies. This warrants regular monitoring and antigenic profiling of the outbreaks strains in relation to the currently used vaccine strain by serological tests such as neutralization test. Two dimensional MNT (2D-MNT) using Bovine Vaccinate Serum (BVS) against vaccine strains is performed regularly to deduce the antigenic relationship of field virus with respective vaccine strains. BHK-21 cells were used as indicator system. The end point titre of the serum was calculated as the reciprocal of the last dilution of serum that neutralizes 100$TCID_{50}$ in 50% of the wells. One-way antigenic relationships (r-value) of the field isolates relative to the reference and field strains was calculated and expressed as the ratio between heterologous/ homologous serum titre. r-values greater than 0.30 indicate that the field isolate is homologous to the vaccine strain and the vaccine is likely to confer protection against challenge with the field isolate. Conversely, values less than 0.30 suggest that the field isolate is so different from the vaccine strain that the vaccine is unlikely to protect.

6.2.1 Serotype O FMD Virus

Genetic characterization

FMDV serotype O is predominant and accounts for about 80% of the outbreaks reported every year in India. VP1 coding region based nucleotide sequence analysis established complex molecular epidemiological scenario with circulation of different genotypes/ lineages/strains of the serotype. Serotype O isolates from India belong to Middle East-South Asia (ME-SA) topotype with less than 15% nucleotide divergence among them. Seven sub-lineages of the virus with more than 8% nucleotide divergence at VP1 coding region namely Branch A, B, C-I, CII, PanAsia I & II and 'Ind2001' have been described in India. The presence of PanAsia lineage was first identified as early as 1982 (in India) and this lineage was detected in many countries in the world during 2000 to 2002. In the year 2001, a new group ('Ind2001') of virus with high genetic divergence from the PanAsia emerged in the field and found to co-circulate with PanAsia viruses between 2001 and 2003. PanAsia II emerged in the year 2003 within the

parental PanAsia I. Though PanAsia I and II dominated the field outbreaks during 2004 to 2008; incidences due to involvement of 'Ind2001' lineage was also noted. Re-emergence and gradual dominance of 'Ind2001' lineage since 2008 in India with limited co-circulation of Pan Asia lineage has been witnessed.

A total of 110 isolates were sequenced at VP1 coding region and subjected to phylogenetic analysis (**Fig 6.1 and 6.2**). Seventy-six isolates were found belong to 'Ind2001' lineage indicating its supremacy in the field. A maximum of 8% divergence at nt. level was observed within 'Ind2001' lineage. The lineage was distributed widely in many states including Karnataka, Kerala, Andhra Pradesh and Tamilnadu (Southern region); Uttar Pradesh and Haryana (Northern region); Gujarat and Maharashtra (Western region); Odisha, West Bengal and Bihar (Eastern region); Madhya Pradesh (Central region) and Nagaland and Tripura (North Eastern region).

Outbreak in Muradnagar, UttarPradesh in March 2012 was attributed to 'Ind2001' lineage. Interestingly viruses isolated from Meerut, Solan, Haridwar, Deoria and Muradnagar were genetically very much similar and formed a separate cluster. This genetic cluster had more than 6% nt divergence from other isolates and did not group with the isolates collected from Uttar Pradesh last year. The isolates from this group also traversed a long way and was responsible for disease outbreak in bulls of frozen semen bank, Cuttack, Odisha. Statistical parsimony analysis indicated that virus probably originated either in Meerut, Uttar Pradesh, from where it moved to different places like Solan (Himachal Pradesh), Deoria (Uttar Pradesh), Haridwar (Uttarakhand) and Cuttack (Odisha).

Very high genetic diversity was detected in southern part of the country with circulation of at least 4 - 5 different genetic clusters within the 'Ind2001' in Kerala and Karnataka. Isolates from Haryana and Gujarat are epidemiologically related and had more than 7% nt divergence from rest of the isolates. Isolates from Odisha (Other than Frozen semen bank) and Madhya Pradesh grouped with strains collected in the respective states in 2010-11 indicating genetic continuity.

Further, there is decline in circulation of PanAsia lineage in the country was noticed with only four isolates collected from Assam and Gujarat grouping with PanAsia1. Though the PanAsia is the dominant lineage in ME-SA topotype in South East Asia, the lineage has been slowly replaced from the field by the Ind2001 lineage.

This year a new group of virus named 'Ind2011' with more than 11% nt divergence from rest of the lineages emerged in Southern region. Twenty eight isolates collected in the states of Karnataka, Tamilnadu, Andhra Pradesh and Kerala formed this group. Earliest occurence as per sample collection date was in September 2011 in Andhra Pradesh. Till March 2012, this lineage caused 20 outbreaks. Statistical parsimony analysis was done to ascertain the probable origin and spread of strains of this lineage. The outgroup which is likely the point of origin is represented by virus collected from Tamilnadu in November and December, 2011 and from Karnataka in January 2012 **(Fig. 6.3)**. At this stage it is unclear whether the lineage first emerged in Andhra Pradesh or in Tamilnadu or Karnataka. This new lineage is currently active in all the four states of southern region. Overall, there is a complex epidemiological scenario in southern region with co-circulation various lineages that pose big threat to rest of the country. The situation is being monitored continuously.

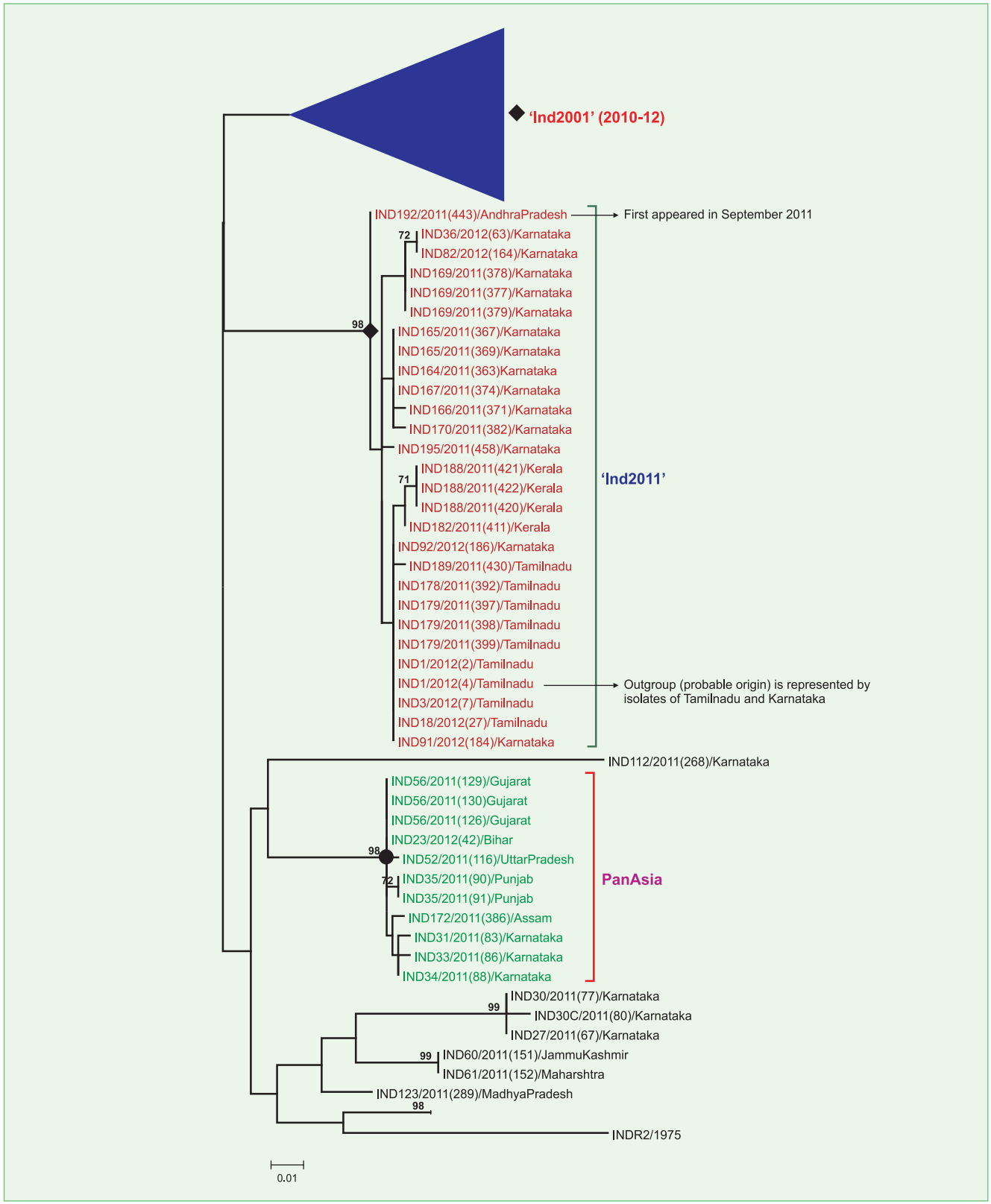


Fig 6.1 Mid point rooted Maximum Likelihood phylogenetic tree at VP1 coding region of Indian serotype O FMD virus isolates during 2011-2012.The tree shows presence of 3 major lineages of FMD virus type O co-circulating in India namely 'Ind2001', PanAsia and New group named 'Ind2011' .

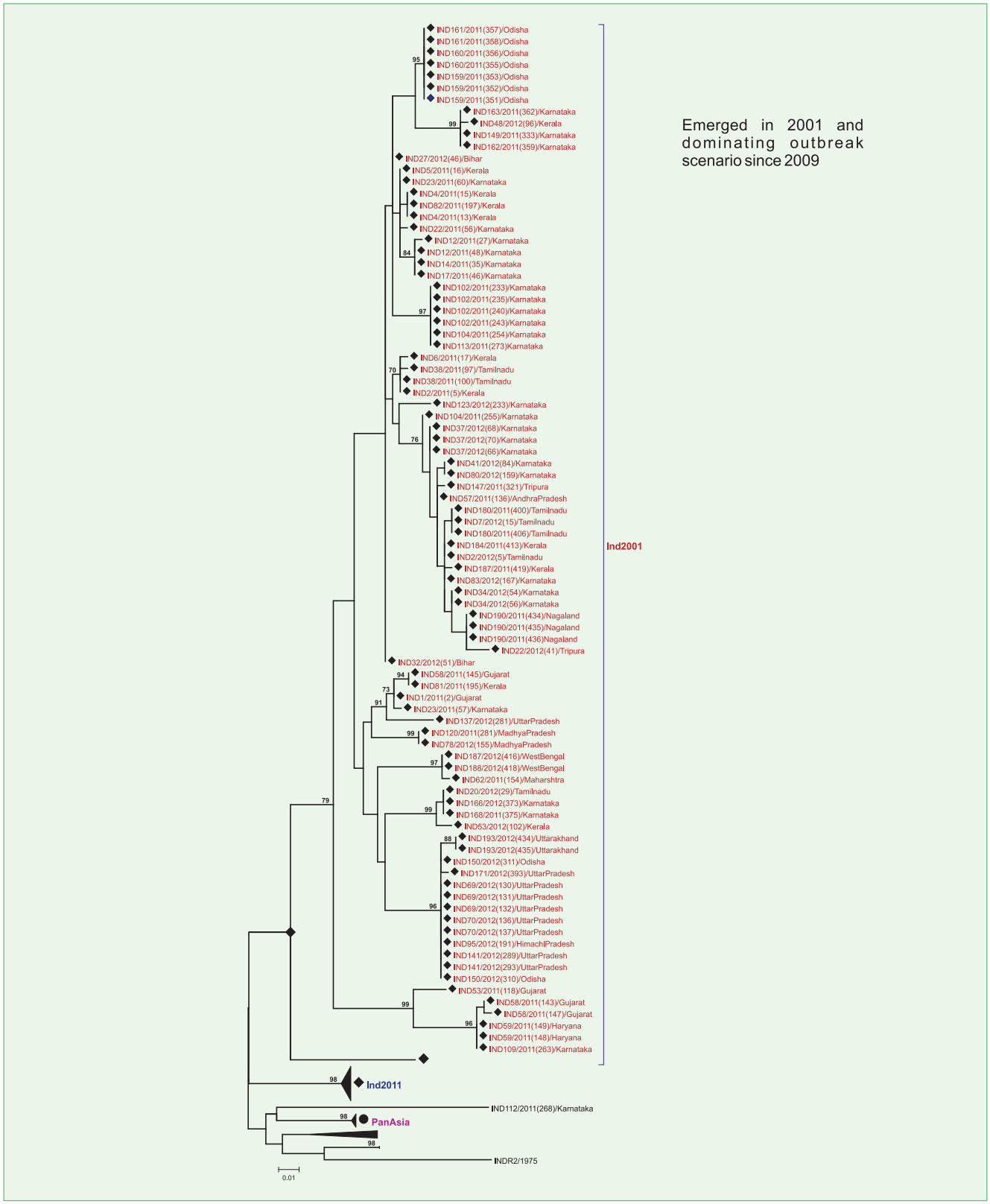


Fig 6.2 Mid point rooted Maximum Likelihood phylogenetic tree at VP1 coding region of 'Ind2001' lineage of FMD virus isolates of serotype O during 2011-2012. The genetic data indicate dominance of 'Ind2001' lineage in major parts of the country.

Antigenic characterization

Twenty three FMDV serotype O isolates were subjected to vaccine matching analysis with currently used vaccine strain INDR2/1975. The isolates were from the states of Gujarat, Andhra Pradesh, Karnataka, Tripura, Odisha, Kerala and Uttar Pradesh. All the isolates showed an r-value of > 0.3 indicating good antigenic coverage of the currently used vaccine strain over the field isolates (**Fig 6.4**). For 'Ind2001' lineage, the relationship value ranged from 0.4-1 and for 'Ind2011', the same varied from 0.45-0.93. From the analysis it is obvious that the emerging 'Ind2011' lineage is well covered antigenically (in-vitro) by currently used vaccine strain INDR2/1975 and there is no exigency.

Assessment of antigenic and genetic variation in serotype O foot-and-mouth disease virus in India: Complete genome sequence analysis and antigenic cartography

Majority of FMD outbreaks are being caused by serotype O FMDV in the country with emergence and re-emergences of genetic variants. Generation of complete genome sequence data helps in better understanding of the molecular complexity of FMDV both at structural and functional level. Regular six monthly vaccination is used as control strategy in the country. 2D-MNT has been used to analyse antigenic coverage of vaccine strain(s) and to select alternate vaccine strains when required. Liquid-phase blocking ELISA (LPBE) has also been used for this purpose.

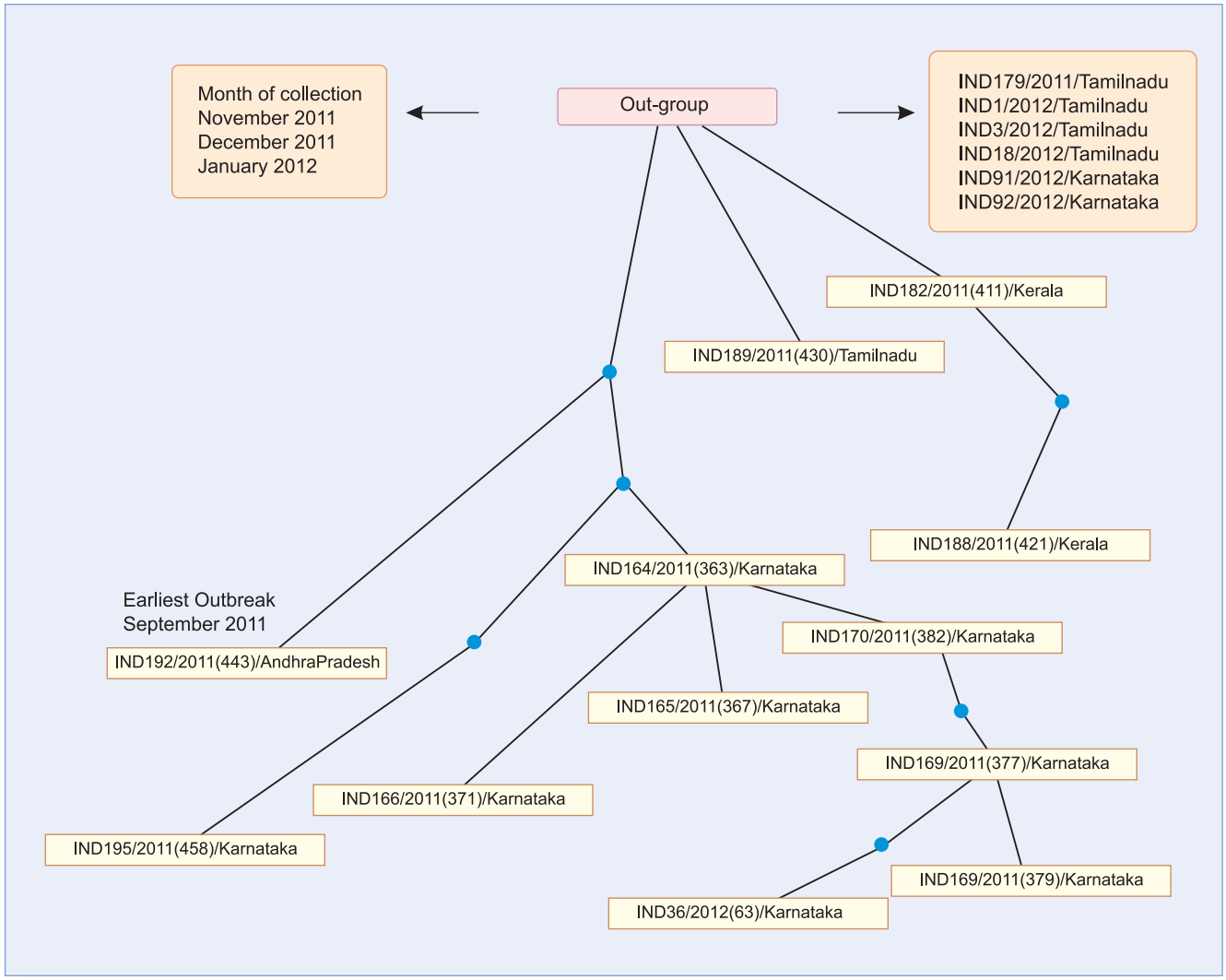


Fig 6.3 Statistical parsimony tree indicating the relationships of 'Ind2011' lineage

Recently, antigenic cartography was used for antigenic analysis of influenza viruses which helps in accurate visualization of antigenic relationship among the isolates quantitatively. Similar approach was used for antigenic analysis of FMDV. As vaccination is the strategy used for FMD control in India, analysis of antigenic coverage offered by current vaccine in field condition is of prime importance and pre-requisite.

Thirty-four serotype O virus strains isolated between 1963 and 2009 covering 17 states were characterized genetically at complete genome level and also evaluated antigenically. The length of RNA genome of FMDV serotype O Indian isolates varied from 8093-8198 nt. and length of coding region was 6999 nts. Maximum divergence at nucleotide level for complete coding (structural and non-structural) region was 10.7%, where as the maximum divergence at the deduced amino acid level was 4.9%. Events of recombination were evident in many of the isolates at structural and non-structural protein coding regions adding to their genetic heterogeneity. Amino acid residues in the coding region were found to undergo positive selection. Majority of the serotype O isolates has P-S change at site 23 of the L^{pro} region indicating hyper-virulence. Lineage specific substitution could be identified in many genomic regions indicating differential evolution pattern. The results obtained from 2D-MNT and LPBE were found comparable for antigenic analysis. Therefore LPBE can be used as an alternative assay to 2D-MNT for vaccine matching. Irrespective of genetic heterogeneity, the circulating type O field isolates were well covered by the in use vaccine strain. Two virus candidates belonging to PanAsia II lineage were found as suitable back-ups for the existing vaccine strain, if required. Antigenic cartography revealed reliable information on antigenic spectrum. Post vaccination serum samples against in-use type O vaccine strain INDR2/75 collected from different districts under FMD CP showed appropriate coverage against all the genetically heterogeneous viruses circulating in the country (**Fig 6.5**).

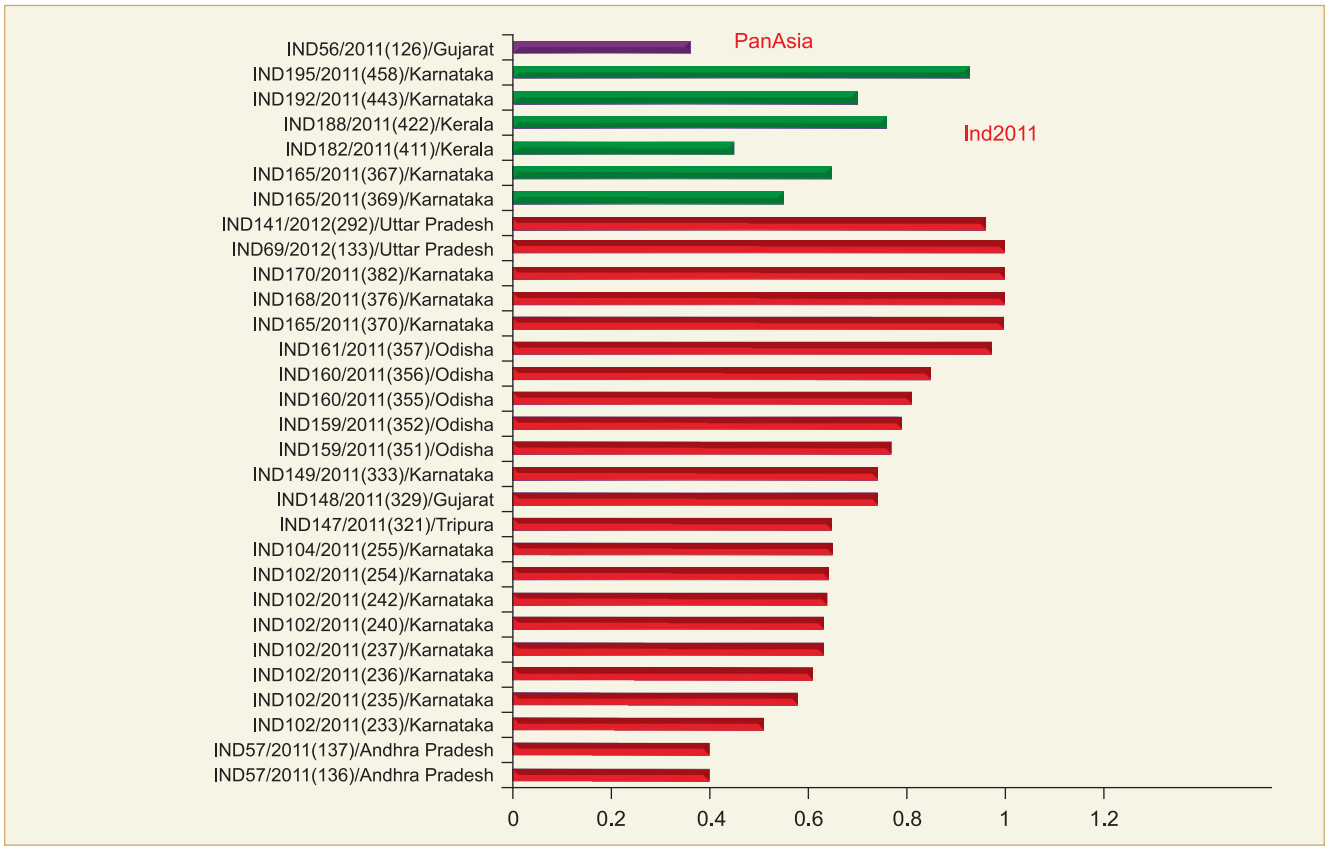


Fig 6.4 Relationship values FMD virus serotype O field isolates of 2011-2012 in relation to currently used vaccine strain INDR2/1975.

Fig 6.5 Neighbour-Joining tree showing phylogenetic relationships between serotype O isolates at complete coding region

Antigenic Cartography

Though genetic variations in the FMDV have been explored to larger extents, assigning different genetic groups in terms of topotypes/lineages, antigenic data are mostly unexplored quantitatively because of difficulties in interpretation, even though antigenicity is the primary criterion for vaccine strain selection. Many approaches are being used for antigenic data analyses of FMDV; like calculating the relationship value

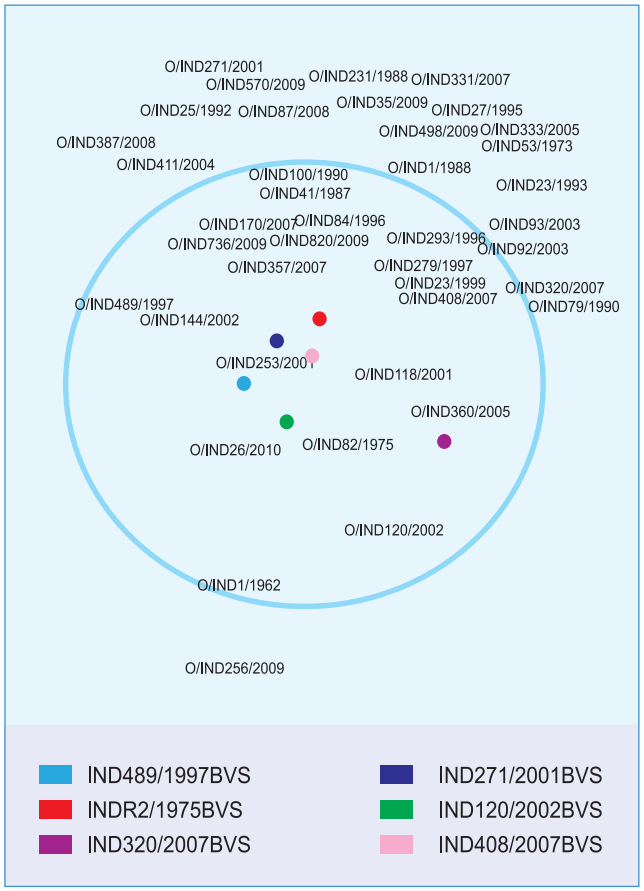


Fig 6.6 Antigenic map (cartogram) generated using the titres of LPBE. Each square indicate the antigenic unit; one square represents an antigenic unit corresponding to a two-fold dilution of antiserum in the immune-assays. The isolates/ antigens are presented as dots of gray colour and the points for different reference sera/antibody (coloured dots) are shown. The circles around each antigen points indicate the range of error, larger the circle lesser is its reliability of its position. Probable protection lines indicating the coverage or range of protection offered by currently used vaccine strain, the circles are drawn using the radius of protection which is calculated considering the maximum and minimum reactivity shown by BVS against INDR2/1975 with various field isolates

('r') as the ratio between heterologous to homologous serum titres. Lapedes and Farber (2001) conceptualized a geometric interpretation of binding assay data, in which each antigen and antiserum is assigned a point in an antigenic map which is based on theoretical concepts of "shape space" such that the distance between an antigen and antiserum in the map directly corresponds to the titres **(Fig 6.6)**. This method offered computational advantages over the ordinal approach, including the reduced running time and fewer local minima, making it suitable to run dataset of both small and larger sizes. The algorithms/software available (http://influenza.nhri.org.tw/ATIVS) was used to place the 34 FMDV serotype O antigens and 1 reference serum on the antigenic map. The titres of these isolates in LPBE were used for the antigenic map construction.

At present, the concept of antigenic cartography is very recent and is in primitive stage in FMDV antigenic analyses. But, this approach has the potential to be a handy tool for vaccine matching and antigenic analysis of FMDV. Apart from this, it provides an easy way for visualization of antigenic relationship among the FMDV circulating in the country in time and space. An analysis using this approach and involving larger number of isolates covering a longer time period can provide clear understanding of antigenic evolution of FMDV in the country which will be helpful in timely preparedness in case of emergence and re-emergences.

6.2.2 Serotype A FMD Virus

Genetic characterization

Among the three serotypes prevalent in India, serotype A virus population is found to be genetically and antigenically most heterogeneous in nature. VP1 coding (1D) region based molecular phylogeny has established circulation of four genotypes {showing more than 15% nucleotide (nt) divergence among them at 1D region} of type A so far in India. Since 2001, genotype 18 has been exclusively responsible for all the field outbreaks and has outcompeted all other previous genotypes. Within the currently circulating genotype 18, a divergent and unique lineage emerged in late part of 2002, which showed an amino acid (aa) deletion at 59^{th} position of VP3 ($VP3^{59}$-deletion group) and dominated the field outbreak scenario in 2002-03. Ever

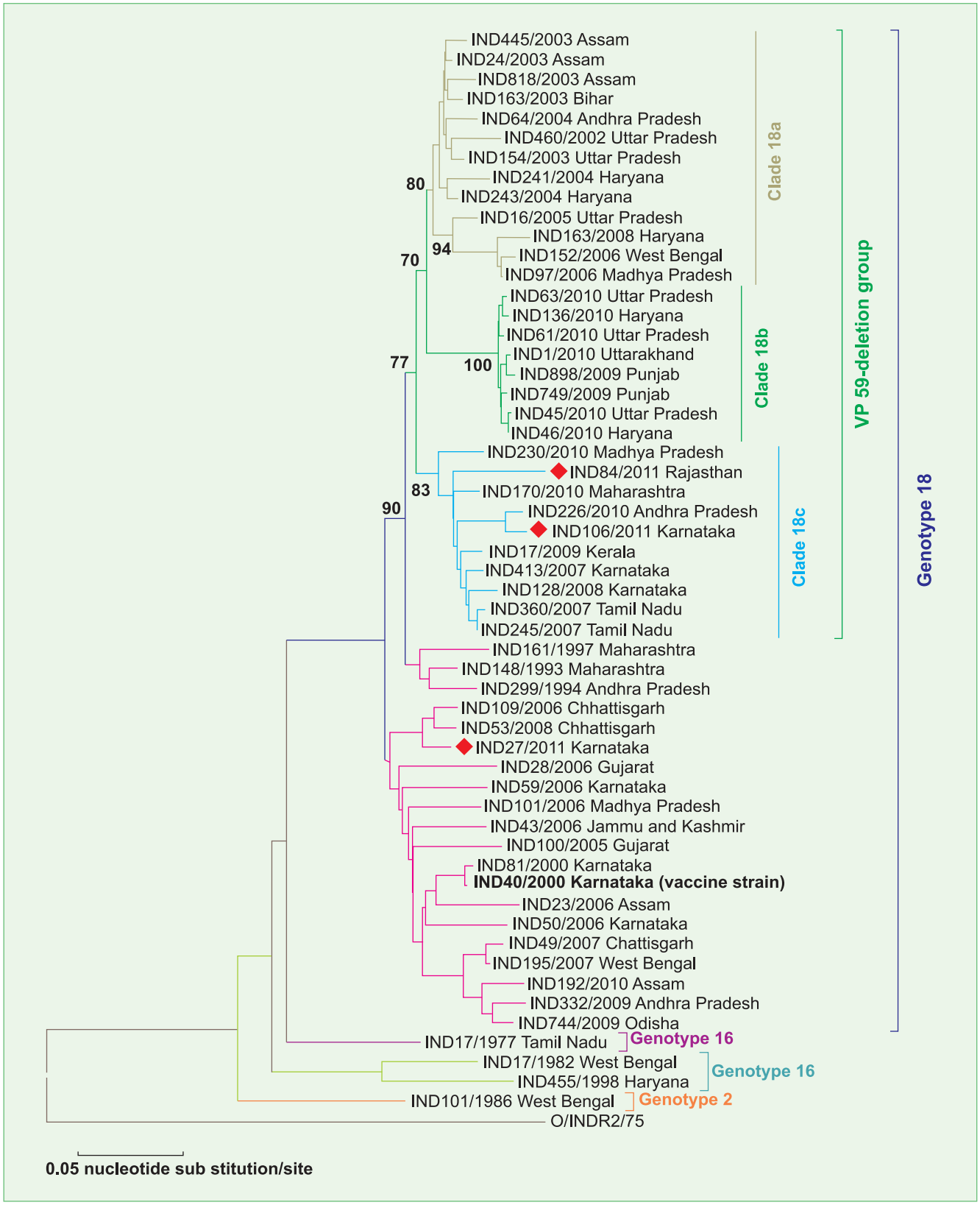


Fig 6.7 Phylogenetic relationship among serotype A FMD virus isolates at VP1 region and genotype classification. Isolates of 2011-12 sequenced are marked with rhombus and the serotype O sequence O/IND R2/75 has been included as an outgroup

since then outbreaks due to this lineage has been diagnosed. This single aa deletion is at an antigenically critical position in the structural protein VP3, which is considered to be advantageous under immune selection pressure.

During the year, 3 field viruses of serotype A isolated from field outbreaks in Karnataka (A IND 27/2011 and A IND 106/2011) and Rajasthan (A IND 84/2011) were subjected to deletion group multiplex PCR for determining their genetic lineage and processed for VP1 sequencing for detailed phylogenomic investigation (**Fig 6.8**). This rapid multiplex PCR assay was developed during 2010-2011 for detection of the dominating VP3[59]-deletion group even before generating sequence data and confirmatory phylogenetic analysis. This method has the potential to also detect the deletion group lineages in the FMD suspected direct clinical tissue material. In this multiplex PCR, deletion group specific bands were obtained for A IND 84/2011 and A IND 106/2011 indicating that both deletion and nondeletion variants have circulated together even in the same state. In Karnataka, both deletion (A IND 106/2011) and nondeletion (A IND 27/2011) variants have caused outbreaks during the same period. The determined 1D sequences were aligned with other Indian sequences available in the data base of PD on FMD. During 2011-2012, all the isolates were found to cluster within genotype 18 in the N-J tree (Fig. 6), but grouped both in the nondeletion and the VP3[59]-deletion lineages. Both the deletion variants (A IND 84/2011_Rajasthan and A IND 106/2011_Karnataka) clustered in Clade 18c of VP3[59]-deletion group; whereas the nondeletion variant, A IND 27/2011_Karnataka shared recent common ancestry with isolates from Chhattisgarh. Clade 18c which was restricted to only southern peninsular India since its first appearance during 2007 has expanded gradually to the central and northern parts of India post-2009. This clade has already spread to adjoining states like Maharashtra and Madhya Pradesh during 2010 and to Rajasthan subsequently in 2011 (**Fig 6.7**).

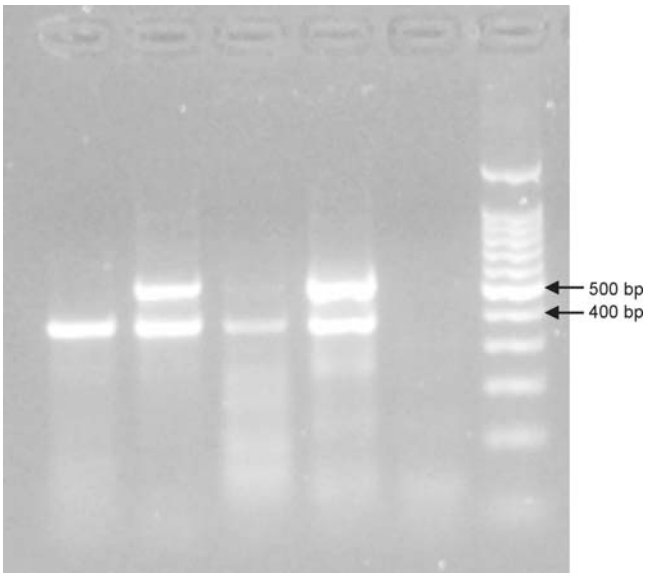


Fig 6.8 Deletion group PCR showing serotype A specific band at 376 bp and deletion group specific band at 518 bp. Lane 1: A IND 27/2011_Karnataka, Lane 2: A IND 84/2011_Rajasthan, Lane 3: A IND 106/2011_Karnataka, Lane 4: Deletion group positive control, Lane 5: BHK-21 cell total RNA as negative control, Lane 6: 100 bp marker (Promega)

Antigenic characterization

Three field isolates were subjected to 2D-MNT using bovine vaccinate serum against the current vaccine strain, A IND 40/2000, and one way antigenic relationship was estimated. The '*r*'-values which directly correlate with antigenic relationship of isolates with the vaccine strain revealed an intermediate range varying from 0.36 to 0.58. As an '*r*'-value of more than 0.3 indicates close antigenic relatedness; it shows that all of the outbreak strains have close antigenic match with the vaccine strain. Hence in the current scenario, it is expected that the vaccine strain A IND 40/2000 would offer optimum antigenic coverage at the face of natural outbreaks, though there is enough genetic divergence.

Experimental evidence for competitive growth advantage of genotype 18 (VII) over 16 (VI): Implications for foot-and-mouth disease virus serotype A genotype turnover in nature

In India, systematic genotype replacement has been observed for serotype A foot-and-mouth disease virus. After a decade of co-circulation of genotypes 16 and 18, genotype 18 emerged as the single dominant genotype since 2001. With the present level of understanding within the theoretical framework of

population genetics, this could be attributable to either better competitive replicative fitness or adaptive fitness of the dominant genotype 18. In this experiment we have attempted to test the first hypothesis i.e., replicative or growth advantage of genotype 18 over 16 *in vitro* in baby hamster kidney (BHK-21) cells through co- and superinfection experiments. Though the in vivo variables during natural circulation of the virus are almost impossible to recreate and may be grossly dissimilar to the experimental environment, this *in vitro* simulation experiment provided a possible explanation for the observed pattern of the natural evolution of genotypes.

To derive possible explanations for such epochal evolution dynamics, *in vitro* intergenotype growth competition experiments involving both co- and superinfection regimes were conducted. Coinfection of BHK-21 cells demonstrated abrupt loss in the genotype 16 viral load with commensurate increase in the load of genotype 18 as measured by the genotype differentiating ELISA, RT-PCR and real-time RT-PCR. The superinfection dynamics was shaped by temporal spacing of infection, where the invading genotype 18 took more number of passages than coinfection to eventually overtake the resident genotype 16. It was speculated that such superior replicative fitness of genotype 18 could have been a possible factor for the ultimate dominance of genotype 18 in nature.

For each MOI, plaque forming units (pfu) ratio of 1:1, 1:10 and 10:1 between genotype 16 and genotype 18 was used in the coinfection study to account for a range of effective population sizes and relative frequencies at inoculation. Both high and low MOI was used to allow for rapid adaptive amplification of preexisting variation in case of low MOI and by reducing the chance of missing any minor variant population in case of high MOI. The virus mixture produced from the first passage was used to initiate the next competition passage at 1 MOI. Likewise, sixteen successive passages (P1–P16) were conducted and culture supernatants were harvested 16–18 h post-infection. For superinfection, BHK-21 cells were first infected with IND 258/1999 virus (genotype 16) at 1 MOI in triplicate wells. Subsequently, each of those three wells received the same infective dose of a virus akin to the current vaccine strain IND 81/2000 (genotype 18) virus but spanning variable time-points (2, 4 and 6 h) following the first infection, as competing viral populations experience different temporo-demographic regimes in nature. A regimen of eight successive passages (P1–P8) was followed. Genotype discriminating whole virus antigen ELISA, RT-PCR and real-time RT-PCR (rRT-PCR) were used in this experiment to quantify the relative genotype specific virus/genome load (**Fig 6.9**).

In this *in vitro* simulation experiment, we have made simplistic assumptions such that each cell and the monolayer represent an individual host and an FMD susceptible animal population, respectively. Likewise transfer of inoculum from previous passage to the subsequent one may be correlated with inter-epidemic spread of virus from one location to the other. Coinfection generally represents the best option for maximizing viral competition for host resources whereas cellular and viral factors modulate the final

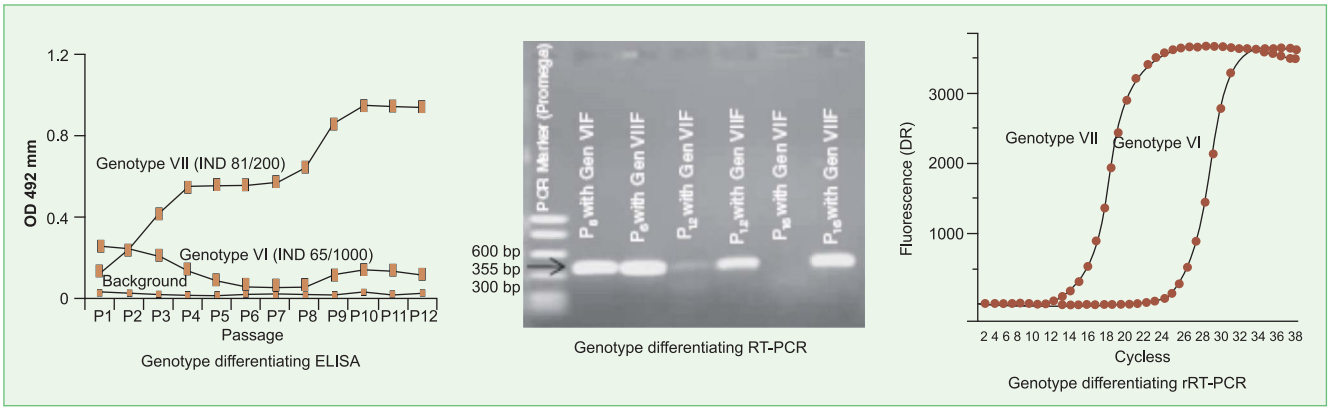


Fig 6.9 Results obtained with culture supernatants of co-infected competition passages in genotype differentiating whole virus antigen ELISA, genotype differentiating RT-PCR (P6, P12 and P16) and genotype differentiating rRT-PCR (P16).

outcome in superinfection dynamics. In all nine coinfection transfer regimes (three different frequencies with each of the three MOI), from the very first passage itself, constant decline in OD value for genotype 16 with proportionate increase for genotype 18 was noticed in the genotype differentiating whole virus antigen ELISA. It took not more than two sequential passages for genotype 18 load to takeover genotype 16 in any of the regimes, though data is only plotted for 1 MOI infection with 10:1 frequency between genotype 16 and 18 combination (Fig. 8). To improve the sensitivity of detection, culture supernatants were also subjected to genotype differentiating RT-PCR. Both genotype RNAs could be detected up to P12, but between 12th and 15th passage in different schedules, amplicon for genotype VI became undetectable (Fig. 9). Further, to detect the difference in the genome concentration at a passage level where genotype 16 went undetected in the conventional PCR, culture supernatants of P16 were subjected to rRT-PCR. A twelve cycle difference in the Ct-values for genotype 16 and 18 suggested genotype 16 had ~4096-fold less template than genotype 18 in the culture supernatants of P16 (**Fig 6.10**).

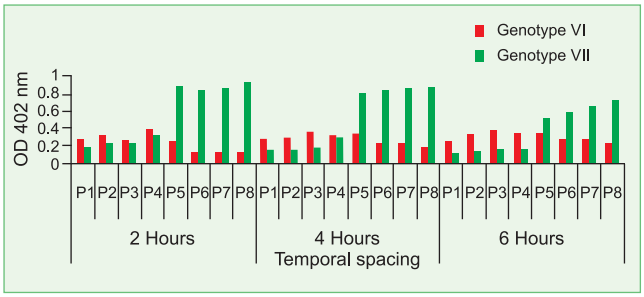


Fig 6.10 Results obtained with culture supernatants of superinfection passages conducted using different temporal spacing in genotype differentiating whole virus antigen ELISA.

Similar to coinfection, after each successive passage in the superinfection regime, there was constant but slow increase in OD value for genotype 18 until P5, where an abrupt increase in OD value took place to overtake the genotype 16 specific absorbance. This is in contrast to coinfection dynamics, where this takeover occurred more rapidly and took just two passages. Moreover, the degree of difference between the genotype specific absorbance distributions was found to be wider and could be achieved faster with reduction in the time interval between inoculations. Earlier experiments have shown that outcome of superinfection dynamics depends on temporal spacing and order of inoculation. Here in super- infection, the outcome was also shaped by temporal spacing of infection suggesting probably shorter time interval offered more opportunities to the invading virus to effectively compete with the resident virus, thereby helping in the faster dominance of the invading genotype 18.

In contrast to the mixed serotype infections of FMDV, where a cycling pattern in concentrations of both competing serotype viruses was observed upon serial cell passage, here no cycling but dominance of one genotype with competitive exclusion of the other was observed, representing a competition system not in stable equilibrium. Preexisting immunity in the susceptible host population due to natural infections might have had a considerable impact in the sense that genotype 16 circulated in the field prior to genotype 18 and poor intergenotypic antigenic coverage has been demonstrated in previous studies. This intergenotype growth competition experiment though did not allow testing effect of immune status, both co-and superinfection have selected for genotype 18 and have led to effective suppression of genotype 16, in proof of better replicative fitness of the former in a competitive atmosphere. Such empirical evidence tempts us to speculate that such *in vitro* advantage might mirror the superior capability of genotype 18 to replicate and disseminate in vivo as well and could have been one of the factors behind the exclusive dominance of genotype 18. Further competition studies, including more field strains of these two genotypes, would strengthen/ validate the findings of the present study.

Complete genetic characterization of vaccine and field strains of serotype A foot-and-mouth disease virus

Extreme antigenic and genetic heterogeneity of serotype A FMD virus population has resulted in change of vaccine strains in India twice in the last decade. In such a situ-ation, complete genomic characterization of the vaccine strains is imperative. Complete genomic characterization of vaccine strains is vital in elucidating their genetic relation-ship with the circulating field

strains, in detecting variation at the antigenically critical residues, in keeping track of any undesirable changes occurring in the vaccine strains upon cell culture propagation, which could compromise the overall antigenic and growth characteristics of the original seed virus, and also in solving any vaccine-related outbreaks with high degree of authenticity. We determined complete genome sequence of two older vaccine strains (IND 17/1977 of genotype 10 and IND 17/1982 of genotype 16) and the current vaccine strain (IND 40/2000 of geno-type 18), and two field strains (IND 258/1999 of genotype 16 and IND 81/2000 of genotype 18).

In the maximum likelihood tree, all the taxa clustered in the three geographically restricted continental topotypes such as Asia, Africa and Euro-South America with high aLRT (>0.8, Likelihood Ratio Test) values (**Fig 6.11**). The overall topol-ogy of the tree reconstructed based on the complete coding region displayed congruence with that for the 1D region.

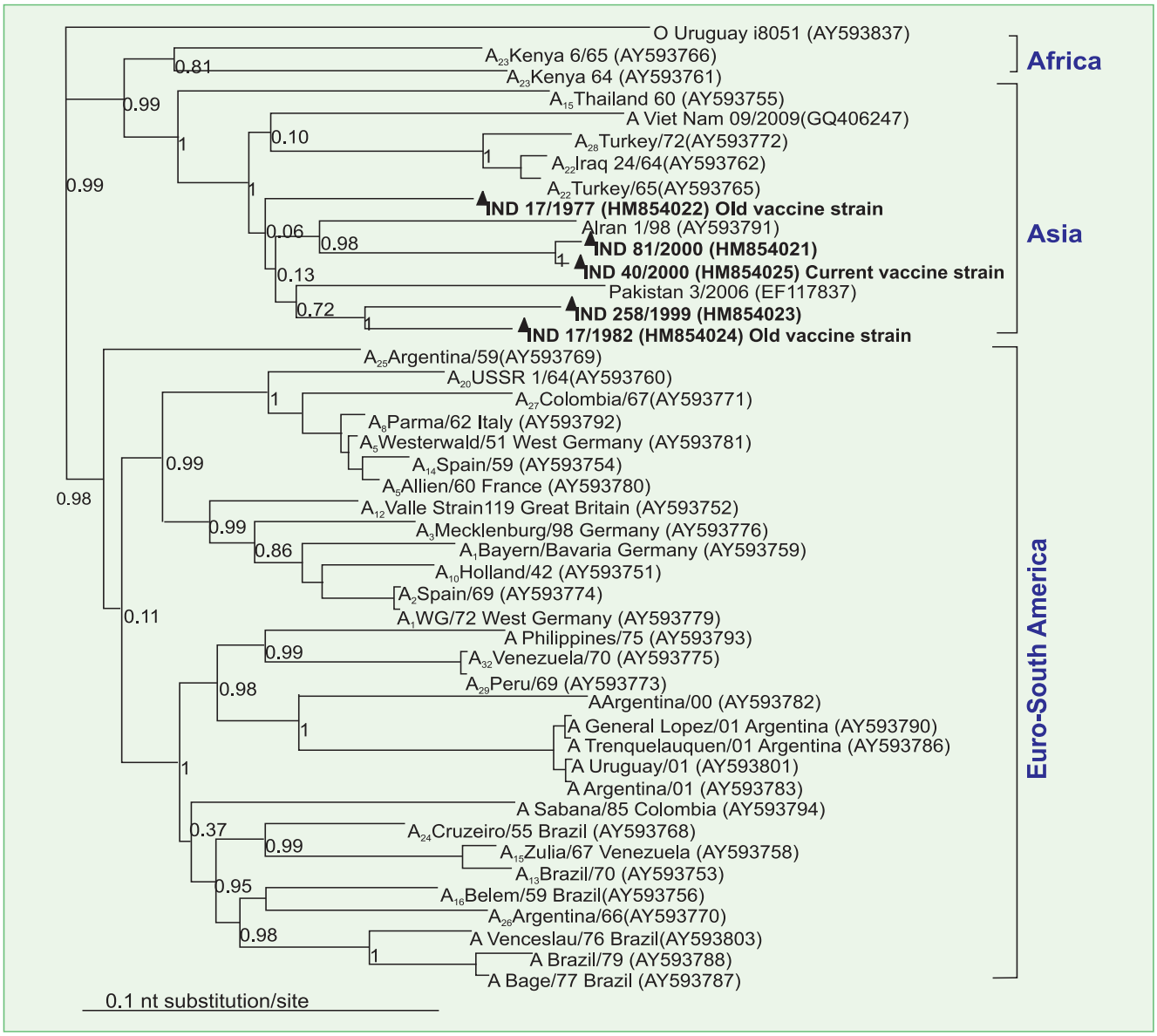


Fig 6.11 Phylogenetic tree of serotype A FMDV strains based on the entire coding region

The aLRT supports are indicated at the nodes. Type O Uruguay iso51 (a type O strain isolated during 1963 in Uruguay) sequence was used as the outgroup in tree reconstruction for better resolution of the topology. Indian virus sequences that were determined in this study are shown in bold face with solid triangles, and topotypes are indicated with brackets.

Divergence in more than 14% of nt in the complete coding region was noticed between the topotypes. The five Indian strains clustered in the Asia topotype and appeared to share the most recent common ancestor with the strains from the Middle East and Pakistan. However, the Indian sequences differed from those strains by more than 11% of nucleotides, indicating their distinct genetic identity. The three vaccine strains revealed 9.4 to 10.2% nt divergence among themselves. The current vaccine strain (A IND 40/2000) grouped closely with a field strain (A IND 81/2000) with just 0.7% nt difference, suggesting their close epidemiological link. Both these strains were recovered within a month's time from the same outbreak area, but from different hosts i.e., clinically affected cattle and buffalo.

For all five Indian strains, the complete coding region was found to be 6999 nt long, encoding 2333 aa without any inser-tions or deletions. The length of the 5t-UTR (considering only 6 'C' residues of the poly(C) tract) varied from 1003 to 1090 nt. The small fragment of 5t-UTR was of uniform length (370 nt) in all the strains, while the redundant PK region in the large fragment immediately following the poly(C) tract revealed block deletions of 43 and 86 nt in IND 17/1982 of genotype 16 and in IND 40/2000 and IND 81/2000 of genotype 18, respectively. Such large deletions disrupted prediction number of PKs. A minimum of two PKs in all five sequences were maintained, probably because of some hitherto unknown evolutionary constraint against any further deletions. Such deletions in the PK region do not seem to fol-low any genotype specific trend as IND 258/1999 of genotype 16 did not reveal any deletion, while IND 17/1982 of the same genotype did so. The 3t-UTR (excluding the poly(A) tract) varied in length between 94 and 101 nt.

A total of 518 aa positions (22.2%) revealed variability in the complete coding region sequence alignment for the global dataset. Unsurprisingly, VP4 followed by 3C, 2B and 3D (in that order) revealed maximum proportion of invariant aa positions, whereas VP1 followed by 3A and L revealed maximum variable positions. Amino acids S44 in VP2 and F164 in VP1 were iden-tified as signatures for Asia topotype. The three vaccine strains differed at 65 aa positions in the capsid region (**Table 6.1**). Further, 13 out of those 65 positions have been shown to be antigenically critical in serotype A virus in earlier studies. Hence, the variability at such positions is likely to affect the antigenic pro-file of these vaccine strains, as evident from the data generated on their one-way antigenic relatedness with the field

Table 6.1 Variability in the capsid proteins of the serotype A Indian vaccine strains used at different times

Strains	VP2 aa																	
	39	68	71	79	85	88	131	134	149	154	189	190	191	193	195	196	201	207
IND 17/1977	G	N	P	E	N	T	E	M	S	M	T	S	T	S	G	E	A	H
IND 17/1982	A	D	T	A	T	K	K	P	S	M	T	S	NG	Q	Q	V	H	
IND 40/2000	G	D	A	E	T	K	E	T	N	T	N	A	G	G	T	Q	A	Y
Strains	VP3 aa																	
	8	37	59	65	70	92	94	139	175	197	204	216						
IND 17/1977	S	Y	D	V	A	S	L	Q	V	Q	V	I						
IND 17/1982	S	Y	N	E	E	A	I	K	T	H	V	V						
IND 40/2000	A	F	N	E	E	S	I	K	T	N	A	I						
Strains	VP1 aa																	
	4	22	24	28	39	41	42	43	44	45	46	48	55	57	59	60	83	84
IND 17/1977	T	T	V	Q	F	R	I	T	A	V	S	T	R	H	H	G	E	G
IND 17/1982	T	V	A	H	S	K	V	N	A	V	S	I	Q	P	N	T	T	D
IND 40/2000	A	T	V	H	F	K	I	G	T	T	N	T	Q	H	H	G	S	G
Strains	VP1 aa																	
	99	102	108	134	138	139	141	142	143	149	154	167	168	170	171	191	197	
IND 17/1977	V	S	H	S	A	P	A	G	R	P	T	V	R	T	T	M	S	
IND 17/1982	S	S	H	S	T	A	I	G	R	A	V	I	R	T	T	L	T	
IND 40/2000	S	G	N	N	A	A	G	R	T	Q	I	I	K	D	A	L	S	

Residues Identified to be antigenically critical are shown in bold face.

viruses in microneutralization tests. The maximum proportion of the variability in the dataset was concentrated around the ^{2}B-^{2}C (aa 40–60) and ^{2}G-^{2}H (aa 140–160) loops of VP1 protein. Although presence of neutralization-relevant antigenic sites on the ^{2}G-^{2}H loop of VP1 has been demon-strated in serotype A virus, no report on the involvement of ^{2}B-^{2}C loop residues in the neutralization of the virus infectivity is available so far. Considering the degree of variability observed in the VP1 ^{2}B-^{2}C loop of field strains of different antigenic make-up, it is presumed that this surface-exposed region might have implications for extending the antigenic repertoire/diversity of serotype A FMDV population similar to other serotypes. The complete genome sequence of vaccine strains generated here would serve as references for future phylogenomic investigations.

Emergence of antigenic variants with in serotype A Foot and Mouth Disease virus in India and evaluation of a new vaccine candidate panel

In an endemic situation, emergence of antigenically distinct strains with the potential to evade immunity from routine vaccination is always a possibility due to continuous evolution of the virus. In routine antigenic analysis, though currently used vaccine strain could cover maximum number of isolates, some of the isolates in VP3^{59}-deletion group of genotype 18 showed low r-value. The situation presently is not alarming as r- values are just an approximation and emergence of occasional antigenic divergence for brief period does not warrant immediate change of vaccine strain. But, emergence of more number of antigenically divergent isolates in future is possible and it stressed the need to look for alternate vaccine candidates that could cover both deletion and non-deletion group isolates, in case of necessity.

A panel of four candidate strains representing both deletion [(IND281/2003 (clade18a), IND360/2007 and IND123/2008 (clade18c)] and non-deletion group (IND195/2007) of Genotype 18 were chosen based on their ability to produce complete classical cytopathic effect (CPE) within 18-24 hours and high infectivity titre. In the initial screening, 19 serotype A field isolates were compared with the vaccine candidates, currently used vaccine strain, IND40/2000 and the previous vaccine strain, IND17/1982. Besides, these isolates were characterised genetically at the capsid coding region.

As neutralizing antibody titres correlate well with protection in the animal, the virus neutralization test is widely used as the reference test system for vaccine strain selection and has been adopted since 1977, all the isolates were subjected to 2D-MNT. IND195/2007, a non-deletion isolate of genotype 18 showed good antigenic match with all the isolates tested including the isolates of VP3^{59}-deletion group. In spite of being in the VP3^{59}-deletion group, IND281/2003 showed good antigenic relationship value with all the isolates of genotype 18. The vaccine candidates IND281/2003 and IND195/2007 even showed high r-value with strains of genotype 10 (IND17/1977) and genotype 16 (IND17/1982) that are currently not prevailing. Eighty four percent (16 out of 19) of the isolates with IND360/2007 showed close antigenic match. One isolate IND17/1977 (Genotype 10) had low r-value with IND123/2008. All the isolates were subjected to unidirectional antigenic analysis with both BVS and RCS against IND123/2008 and antigenic coverage was found to be similar in both the cases. Although, there was a variation in the r-value between the RCS and BVS, the values obtained were comparable and information could be derived. This shows that use of RCS will not affect the final inference of the test results.

Analysis of the un-rooted phylogenetic tree on P1 region of serotype A field isolates under study revealed that the isolates could be grouped in to two major clusters in genotype 18 *viz*; VP3^{59} -deletion group (IND407/2007 to IND281/2003) and non-deletion group (IND28/2006 to IND281/2003). Six of the isolates were placed in non-deletion group which contains currently used vaccine strain and ten isolates were placed in VP3^{59}-deletion group indicating their dominance in the field. Within VP3^{59}-deletion group, two isolates were clustered in clade18a, one in clade18b and seven in clade18c. None of the isolates clustered in genotype 10 or 16 (**Fig 6.12**).

The maximum within group nucleotide (nt) divergence among VP3^{59}-deletion and non-deletion group was found to be 7.1% and 9.9%, respectively.

Between these two groups, the divergence at nt level ranged between 8.6 and 11.8%. At amino acid (aa) level, a maximum of 5.7% and 5.1% divergence was observed in non-deletion and VP3[59]-deletion group, respectively. The aa divergence between these two groups varied from 3.3 to 6.8%. The currently used vaccine strain IND40/2000 had 9.6 to 10.2% divergent at nt level with VP3[59]-deletion group isolates and at amino acid level, the divergence was 4.3 to 5.9%. The nt divergence of VP3[59]-deletion group isolates ranged 8.4 to 10.5% and 1.1 to 5.1% with IND195/2007 and IND281/2003, respectively. At aa level, divergence was between 3.5 to 5.4% with IND195/2007 and 1.9 to 3.9% with IND281/2003. The other two candidates IND123/2008 and IND360/2007 had maximum divergence of 5.5 and 5.2% at nt level, 5.17 and 4.2% at aa level with VP3[59]-deletion group isolates.

Alignment of nt sequences of P1 region revealed common substitutions that are unique VP3[59]-deletion group compared to non-deletion isolates. These differences were found at many nt positions (G-A at 117, 264, 417, 433, 663, 1011 and 1770; C-T at 267, 283, 378, 496, 720, 1074, 1629 and 1923; T-C at 546 and 1386; A-G at 1458 and 2071; C-A at 162; A-C at 518; C-G at 621; T-G at 1183; G-C at 1290; R-T at 1579). In order to see whether any correlation exist between aa variation and pattern of r-value, deduced aa in the P1 region of VP3[59]-deletion group isolates were compared with vaccine and candidate vaccine strains. But we could not arrive at any definite conclusions. When antigenically critical residues were compared, the VP3[59]-deletion group isolates had 3 changes [VP3-139 (K-Q/R), VP1-83 (S-D) and 170 (D-T)] with IND40/2000, two changes with IND195/2007 [VP3-139(K-Q/R) and

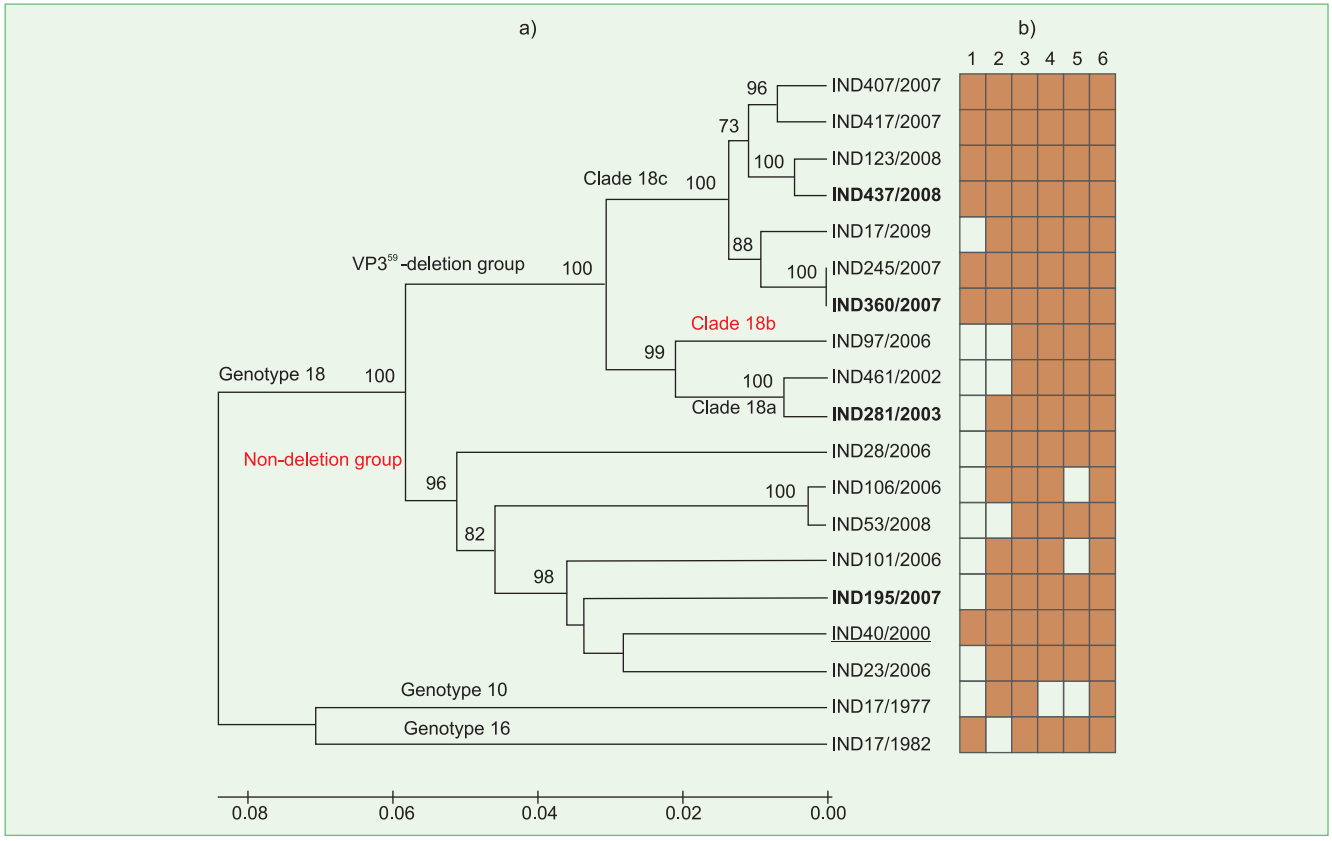


Fig 6.12 UPGMA tree showing the phylogenetic relationship and genotype classification of FMDV serotype A isolates. The tree was constructed by the alignment of full-length nucleotide sequences of P1 region of FMDV serotype A isolates. The numbers at each node represent the percentage boot strap scores (10,000 replicates). b) Schematic diagram showing one-way antigenic relationships (r-values) of type A field isolates with reference strains(1: IND 17/1982, 2: IND 40/2000, 3: IND 281/2003, 4: IND 123/2008, 5: IND360/2007, 6: IND195/2007 in 2D-MNT: r-values >0.3(black filled box) indicates that the existing vaccine/reference strains provides enough protection; and <0.30(empty box) indicates antigenic divergence of the field isolates.

VP1-170(N-T)] and one change with IND281/2003 [VP3-139(R-Q/R)], IND360/2007 [VP3-139(Q-Q/R)] and IND123/2008 [VP3-139(Q-Q/R)]. VP3[59]-deletion group specific signatures were found at positions including VP3-54 (F-L), VP1-3 (T-S) and VP1-167(I-V) implying probably their differential evolution. In the ^{2}G-^{2}H loop, TRGD at VP1 143-146 position (numbering as per IND40/2000) and 2 Leucine (L) residues at 147 and 150 positions were fully conserved in all the isolates.

From antigenic analysis it can be seen that majority (52.6%) of the isolates (10 out of 19) were significantly different from the previous vaccine strain IND17/1982 indicating the poor inter-genotypic antigenic coverage (**).** Interestingly, six of the seven isolates belonging to clade 18c of VP3[59]-deletion group (IND245/2007, IND360/2007, IND407/2007, IND417/2007, IND123/2008 and IND437/2008) showed r-value more than 0.3 with IND17/1982 and isolate IND17/2009 had an r-value of 0.29. Though all the recent isolates belong to genotype 18, three of them (IND461/2002, IND97/2006 and IND53/2008) showed poor antigenic match with the current vaccine strain IND 40/2000. Two of the three isolates which showed antigenic deviation belonged to VP3[59]-deletion group (IND461/2002 and IND97/2006) and one (IND53/2008) belonged to non-deletion group. IND40/2000 was selected as vaccine candidate when maximum numbers of serotype A outbreaks were caused by the non-deletion isolates of genotype 18.

In conclusion, the existence of two distinct clusters of genotype 18 including various sub-lineages implies that the serotype A FMD virus is under the process of continuous evolution. The present study identified a panel of two candidate vaccine strains from genotype 18 one representing deletion group (IND281/2003) and the other non-deletion group (IND195/2007) as potential alternate vaccine candidates for use in case of necessity. Although these two candidate vaccine strains cover the circulating field outbreak viruses recovered during 2002-09, the investigation has to continue further with future outbreak viruses to establish their antigenic superiority over IND40/2000 in covering antigenic divergence that is likely to continue.

Table 6.2 One way antigenic relationship (r-value) of FMDV serotype A field isolates in 2D-MNT. The currently used vaccine strain is underline and the candidate vaccine strains are italicized.

Isolate	Genotype/sub-lineages	IND17/1982 (RCS)	IND40/2000 (BVS)	IND195/2007 (RCS)	IND123/2008 (BVS)	IND123/2008 (RCS)	IND 360/2007 (BVS)	IND281/2003 (RCS)
IND17/1977	10	<0.2	1.00	0.32	<0.2	0.26	<0.2	0.38
IND17/1982	16	**1.00**	<0.2	0.4	0.86	1.00	1.00	0.67
IND40/2000	18 (non-deletion)	0.33	**1.00**	0.66	0.44	0.45	0.47	0.54
IND195/2007	18 (non-deletion)	<0.2	0.7	**1.00**	1.00	0.91	0.35	1.00
IND23/2006	18 (non-deletion)	<0.2	0.68	0.66	1.00	0.72	0.40	0.55
IND28/2006	18 (non-deletion)	<0.2	1.00	0.52	0.33	0.63	0.79	0.75
IND101/2006	18 (non-deletion)	<0.2	0.62	0.66	0.54	0.80	<0.2	0.41
IND106/2006	18 (non-deletion)	<0.2	1.00	0.47	0.91	0.48	0.29	0.33
IND53/2008	18 (non-deletion)	0.25	<0.2	0.72	0.38	0.55	0.31	0.44
IND123/2008	18 (Clade 18c)	0.50	0.59	0.54	**1.00**	**1.00**	1.00	0.73
IND407/2007	18 (Clade 18c)	0.33	0.75	0.36	0.55	0.95	0.36	0.63
IND417/2007	18 (Clade 18c)	0.31	0.70	0.45	0.54	0.95	0.36	0.83
IND437/2008	18 (Clade 18c)	0.58	0.38	0.43	1.00	1.00	0.79	1.00
IND360/2007	18 (Clade 18c)	0.33	0.75	0.52	1.00	0.95	**1.00**	0.69
IND245/2007	18 (Clade 18c)	0.6	0.48	0.50	0.48	0.91	1.00	0.55
IND17/2009	18 (Clade 18c)	0.29	0.31	0.60	0.63	1.00	0.76	0.8
IND281/2003	18 (Clade 18a)	<0.2	1.00	0.72	1.00	0.96	0.47	**1.00**
IND461/2002	18 (Clade 18a)	<0.2	<0.2	1.00	0.79	0.79	0.45	0.52
IND97/2006	18 (Clade 18b)	<0.2	<0.2	0.60	1.00	0.72	0.41	0.80

6.2.3 Serotype Asia1 FMD Virus

Genetic characterization

In India around 12% of the FMD outbreaks are caused by serotype Asia1 virus. Eastern, western and central regions are considered to be endemically infected with this serotype. This year also, outbreaks owing to serotype Asia 1 have been recorded in the states of Gujarat, Maharashtra, Chhattisgarh and Goa in the Western region; West Bengal in the Eastern region; Chhattisgarh in the Central region and Assam in the North Eastern region. High number of outbreaks due to serotype Asia 1 have been recorded in Northern Karnataka which shares border with Maharashtra and Goa. The state of Karnataka remained completely free of serotype Asia 1 during the last five years and its re-appearance is of epidemiological significance highlighting the importance of control of cross border animal movement. A single outbreak in Kerala was recorded after a gap of three years.

This year a total of twenty seven isolates of serotype Asia 1 was subjected to phylogenetic analysis using Maximum likelihood method implemented in MEGA 5.05. The analysis revealed circulation of lineage C in the country (**Fig 6.13**). Lineage C has been exclusively causing all the serotype Asia 1 outbreaks in India since 2005. Isolates of Karnataka were closely related to isolates in the western cluster (less than 2% divergence) confirming virus movement. There is a unique cluster of virus circulating in Eastern and North Eastern states (Eastern cluster) and not found elsewhere in the country. More genetic diversity exists in the western cluster as isolates were placed in many small groups.

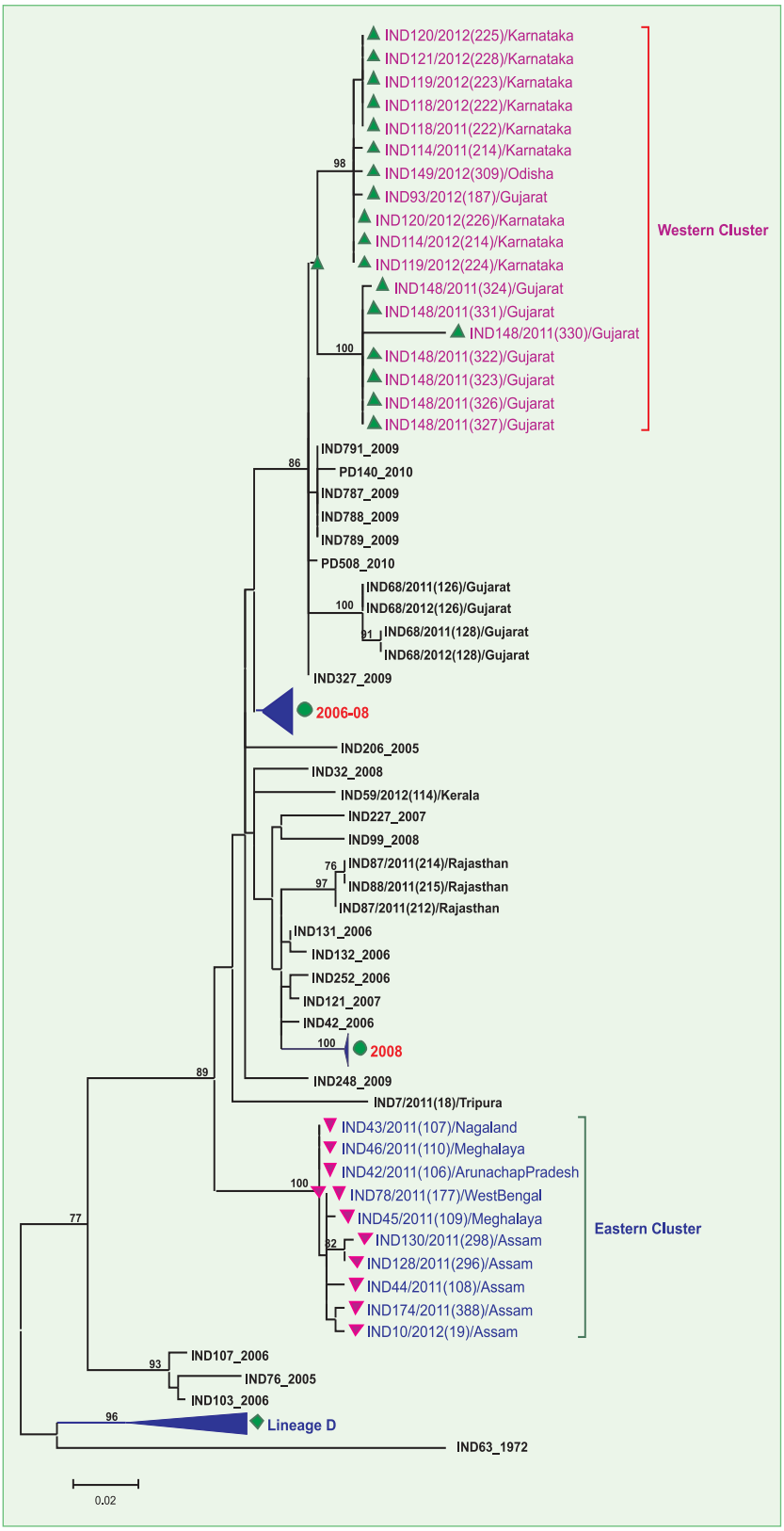


Fig 6.13 Mid point rooted Maximum Likelihood phylogenetic tree at VP1 coding region of FMD virus isolates of serotype Asia1 during 2011-2012. Lineage C is in circulation in the country since 2005.

Antigenic characterization

In the current year, 08 FMDV Asia 1 collected from two different outbreaks were subjected to antigenic analysis using anti-146S bovine vaccinate serum against the Indian serotype Asia1 vaccine strain, IND63/1972. Seven of the eight isolates were from outbreaks in Gujarat, and one isolate was from West Bengal. All the isolates showed an r value of more than 0.3 with the in-use vaccine strain indicating its appropriate antigenic coverage.

6.3 Development of Loop Mediated Isothermal Amplification (LAMP) assay for FMD diagnosis

Laboratory diagnosis of FMDV is generally based on ELISA and mPCR. For rapid detection of FMDV, a number of nucleic acid amplification assays have been described. Among these, LAMP is well known for possessing superior isothermal reaction characteristics and is widely regarded as a simple, rapid, specific and cost-effective nucleic acid analysis method for diagnosis. LAMP assay targeting 3D gene was developed and evaluated for detection of FMDV infection. The results demonstrated that all the three FMDV serotypes viz O, A and Asia1 tested could be detected with high sensitivity and specificity. The assay was also evaluated on field samples and found to be more sensitive than sandwich ELISA and mPCR. The results obtained with bovine semen samples also showed a high sensitivity of the LAMP compared to ELISA and mPCR. As the results of RT-LAMP can be visualized directly by the naked eye (**Fig 6.14**) as change in colour (violet to sky blue) without the requirement of any special equipment, makes it suitable for use as an "on- site" test for rapid diagnosis of FMDV. Apart from the high levels of analytical and diagnostic accuracy and speed of detection, another important practical advantage of the LAMP technique is that it is suitable for use in resource-poor settings. In addition, only basic molecular and technical skills are required for execution of the assay procedure, and interpretation of the results is as simple as a visual evaluation of colour change in the reaction mix. The test was found suitable for clinical samples with very low virus load, and the minimum detection limit was 0.01 fg/ microliter as against 1000 fg/microliter in mPCR (**Fig 6.15**).

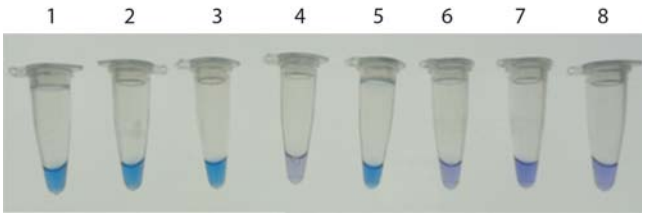


Fig 6.14 Tube(s) with a positive reaction shows a color change to sky blue, which can be distinguished from the violet color of a negative reaction

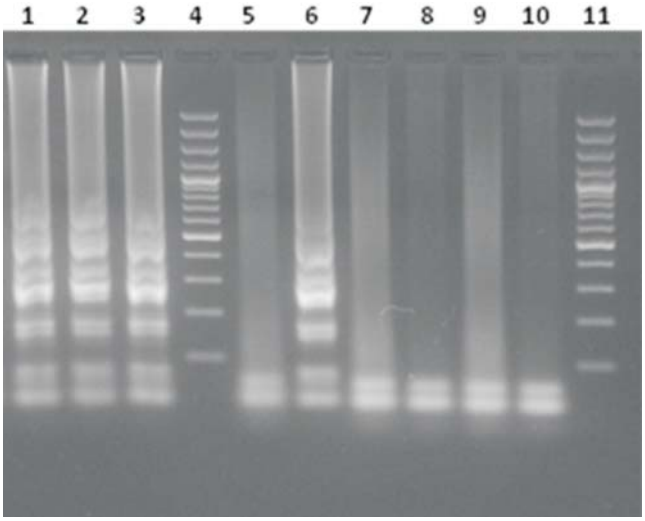


Fig 6.15 Agarose gel electrophoresis of RT-LAMP products. A ladder like pattern in positive samples can be seen. Lanes 1–3: FMDV serotypes O, A and Asia1, respectively. Lane 4 and 11: 100-bp plus DNA ladder (Fermentas). Lane 5: negative control, Lane 6: positive control, Lane 7, 8, 9 and 10: BTV, CSFV, healthy tongue epithelium of goat and sheep, respectively.

7.0

National FMD Virus Repository

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 62 virus isolates (46 type O, 3 type A and 13 Asia 1) were added to the repository during the reported period (**Table 7.1**). At present the National FMD virus Repository holds a total of 1774 isolates (O-1148, A-279, C-15 and Asia 1-332).

Table 7.1 Details of the virus isolates added to National FMD Virus Repository during 2011-12

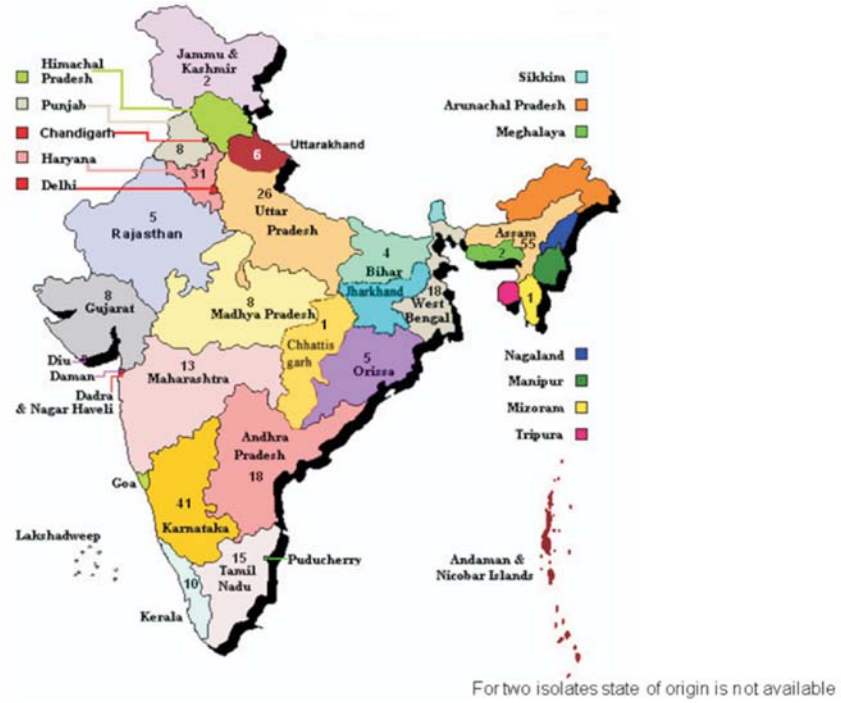
S.No	Designation	Cell and Passage No.	Place of Origin	Host	Serotype
1	PD56/2011	BHK-21, P11	Karnataka	Cattle	O
2	PD02/2011	BHK-21, P9	Gujarat	Cattle	O
3	PD83/2011	BHK-21, P9	Karnataka	Cattle	O
4	PD86/2011	BHK-21, P9	Karnataka	Cattle	O
5	PD87/2011	BHK-21, P9	Karnataka	Cattle	O
6	PD116/2011,	BHK-21, P11	Uttar Pradesh	Buffalo	O
7	PD118/2011	BHK-21, P9	Gujarat	Buffalo	O
8	PD 117/2011	BHK-21, P9	Gujarat	Buffalo	O
9	PD 126/2011	BHK-21, P9	Gujarat	Cattle	O
10	PD 136/2011	BHK-21,P7	Andhra Pradesh	Nilgai	O
11	PD 137/2011	BHK-21,P7	Andhra Pradesh	Nilgai	O
12	PD 28/2011	BHK-21,P16	Karnataka	Cow	O
13	PD 154/2011	BHK-21,P8	Maharashtra	Cattle	O
14	PD233/2011	BHK-21,P8	Karnataka	Cow	O
15	PD234/2011	BHK-21,P8	Karnataka	Cow	O
16	PD235/2011	BHK-21,P8	Karnataka	Cow	O
17	PD236/2011	BHK-21,P8	Karnataka	Cow	O
18	PD237/2011	BHK-21,P8	Karnataka	Cow	O
19	PD240/2011	BHK-21,P8	Karnataka	Cow	O
20	PD242/2011	BHK-21,P8	Karnataka	Cow	O
21	PD254/2011	BHK-21,P9	Karnataka	Cow	O
22	PD255/2011	BHK-21,P8	Karnataka	Cow	O
23	PD321/2011	BHK-21,P8	Tripura	Cattle	O
24	PD333/2011	BHK-21,P6	Karnataka	Cow	O
25	PD329/2011	BHK-21,P9	Gujarat	Cattle	O
26	PD 351/2011	BHK-21,P8	Odisha	Bovine	O
27	PD 352/2011	BHK-21,P8	Odisha	Bovine	O
28	PD 353/2011	BHK-21,P8	Odisha	Bovine	O
29	PD 355/2011	BHK-21,P8	Odisha	Bovine	O
30	PD 356/2011	BHK-21,P8	Odisha	Bovine	O

S.No	Designation	Cell and Passage No.	Place of Origin	Host	Serotype
31	PD 357/2011	BHK-21,P8	Odisha	Bovine	O
32	PD370/2011	BHK-21,P10	Karnataka	Cow	O
33	PD376/2011	BHK-21,P10	Karnataka	Cow	O
34	PD382/2011	BHK-21,P10	Karnataka	Cow	O
35	PD 04/2012	BHK-21,P9	Tamilnadu	Bovine	O
36	PD 28/2012	BHK-21,P11	Tamilnadu	Bovine	O
37	PD 41/2012	BHK-21,P6	Tripura	Bovine	O
38	PD 42/2012	BHK-21,P8	Bihar	Bovine	O
39	PD 52/2012	BHK-21,P6	Karnataka	Bovine	O
40	PD 73/2012	BHK-21,P7	Karnataka	Bovine	O
41	PD87/2012	BHK-21,P8	Karnataka	Bovine	O
42	PD88/2012	BHK-21,P8	Karnataka	Bovine	O
43	PD94/2012	BHK-21,P8	Kerala	Cattle	O
44	PD123/2012	BHK-21,P11	Jammu& Kashmir	Cattle	O
45	PD133/2012	BHK-21, P8	Uttar Pradesh	Cow	O
46	PD159/2012	BHK-21,P10	Karnataka	Bovine	O
47	PD177/2011	BHK-21,P8	West Bengal	Bovine	Asia 1
48	PD322/2011	BHK-21,P3	Gujarat	Cattle	Asia 1
49	PD323/2011	BHK-21,P3	Gujarat	Cattle	Asia 1
50	PD324/2011	BHK-21,P3	Gujarat	Cattle	Asia 1
51	PD326/2011	BHK-21,P3	Gujarat	Cattle	Asia 1
52	PD327/2011	BHK-21,P3	Gujarat	Cattle	Asia 1
53	PD330/2011	BHK-21,P3	Gujarat	Cattle	Asia 1
54	PD331/2011	BHK-21,P3	Gujarat	Cattle	Asia 1
55	PD20/2012	BHK-21,P10	Assam	Cattle	Asia 1
56	PD21/2012	BHK-21,P11	Assam	Cattle	Asia 1
57	PD24/2012	BHK-21,P9	Assam	Cattle	Asia 1
58	PD126/2012	BHK-21,P8	Gujarat	Cow	Asia 1
59	PD128/2012	BHK-21,P8	Gujarat	Bullock	Asia 1
60	PD68/2011	BHK-21,P9	Karnataka	Bullock	A
61	PD202/2011	BHK-21,P8	Rajasthan	Cattle	A
62	PD259/2011	BHK-21,P9	Karnataka	Cattle	A

State-wise distribution of serotype O isolates (n=1148) preserved in National FMD virus Repository, PDFMD, Mukteswar

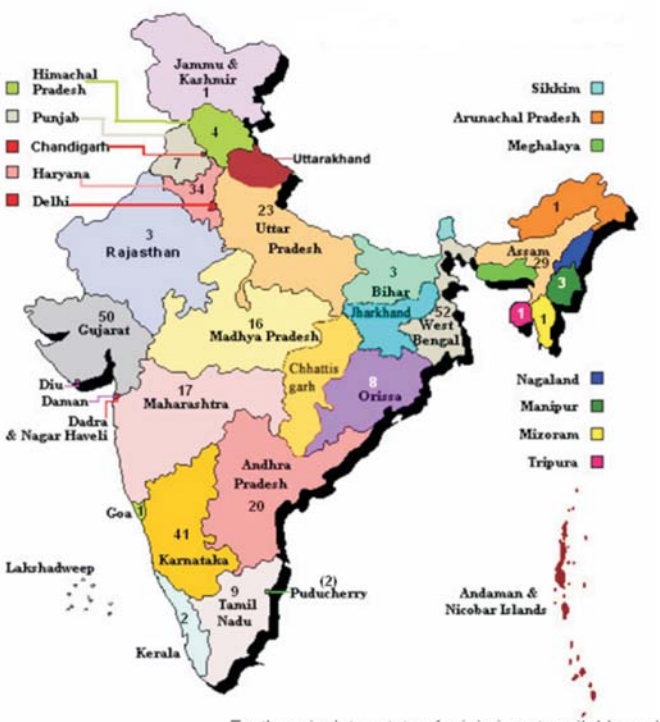
For eleven isolates state of origin is not available and one isolate is from Nepal

State-wise distribution of serotype A isolates (n=279) preserved in National FMD virus Repository, PDFMD, Mukteswar



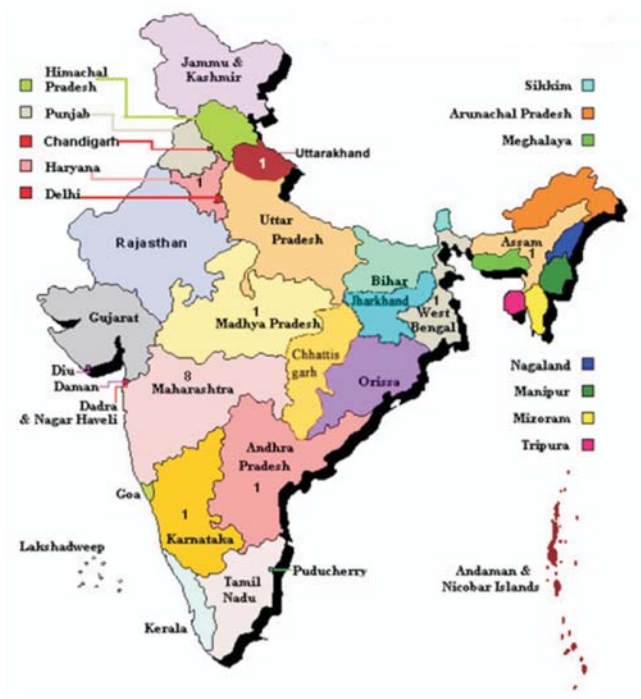
For two isolates state of origin is not available

State-wise distribution of serotype Asia 1 isolates (n=332) preserved in National FMD virus Repository, PDFMD, Mukteswar



For three isolates state of origin is not available and one isolate is from Bhutan

State-wise distribution of serotype C isolates (n=15) preserved in National FMD virus Repository, PDFMD, Mukteswar



State-wise distribution of FMD virus (serotype O, A, C and Asia 1) isolates (n=1774) preserved in National FMD virus Repository, PDFMD, Mukteswar

For sixteen isolates, state of origin is not available and one isolate each is from Nepal & Bhutan

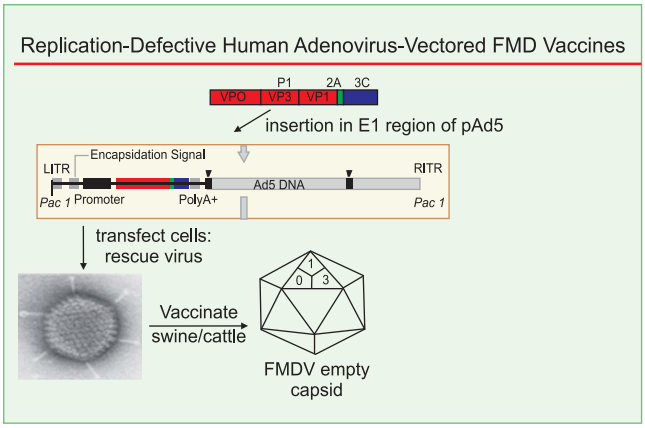
8.0

New Research Projects

S.No.	Project Title	PI
1	Maintenance of the National FMD virus repository	Dr. B. Pattnaik
2	Antigenic and genetic variation of FMDV serotype O and A in the presence and absence of immune selection	Dr. A. Sanyal
3	Development of alternate assay system for FMD vaccine matching and efficacy	Dr. A. Sanyal
4	Genetic and antigenic characterization of FMDV Serotype O	Dr. A. Sanyal
5	Production, standardization and supply of diagnostic reagents for FMD diagnosis and surveillance	Dr. B. B. Dash
6	Seromonitoring of vaccinal immunity against FMD	Dr. B. B. Dash
7	Serosurveillence of FMD in India	Dr. B. B. Dash
8	Antigenic and molecular epidemiology of FMD virus Serotype A	Dr. J.K. Mohapatra
9	Construction of an infection cDNA clone for a serotype Asia 1 FMDV	Dr. J.K. Mohapatra
10	Lineage differentiating RTPCR for serotype O FMDV	Dr. Saravanan S.
11	Molecular analysis and vaccine matching of FMD virus Serotype Asia 1	Dr. Saravanan S.
12	Pathogenesis of FMDV and its early diagnosis in mice model	Dr. M. Rout
13	Surveillance and monitoring of FMD in ovine, caprine and porcine species in India	Dr. M. Rout
14	Development of high throughput LPBE assay for estimation of antibodies to structural proteins of FMD virus	Dr. G. K. Sharma
15	Development of recombinant antibody against 3ABC NSP for use in DIVA ELISA	Dr. G. K. Sharma
16	Generation of infectious FMD virus serotype O from cloned cDNA using the RNA Polymerase 1	Dr. J. K. Biswal
17	Development of recombinant 2B NSP DIVA ELISA for FMD	Dr. J. K. Biswal
18	Validation of LAMP kit for diagnosis of FMD in field samples	Dr. R. Ranjan
19	Spatial and temporal distribution of FMD in India during 2001-2011	Dr. Muniswamy K

Collaboration with USDA-ARS (Under GFRA): Effective molecular vaccines against FMD

Under collaborative programme entitled "Antigenic and genetic characterization of Foot and Mouth Disease viruses in India: Application to effective molecular vaccines"; vide cooperative agreement no. 58-1940-9-208F between USDA and ICAR, a scientist from PDFMD and another from IVRI, Bangalore Campus were deputed to Plum Island Animal Disease Center (PIADC), New York, USA for a period of 6 months, commencing from 11-5-2011 to 14-11-2011 for production of recombinant constructs. The scientists at PIADC have pioneered the research model involving replication defective human adenovirus serotype 5 (hAd5) for developing vaccines and immunotherapeutics against animal viral diseases including FMD. This technology was used for production of hAd5 constructs with Indian FMD virus sequences.



The Capsid expression cassette

clal-atg-VP4-VP2-VP3-VP1-2A-2B-3B'-C-tag-*Xbal*

NT—255 654 663 639 48 462 195 639

During the deputation, recombinant hAd5-FMD virus capsid construct was developed against five strains of Indian FMDV (O IND R2/1975, Asia 1 IND 63/1972, A IND 40/2000, A IND 195/2007 and A IND 281/2003) including the three vaccine strains currently being used in India. Such vaccines are thought to be safe to produce, stable and can elicit both humoral and cellular arms of immune response. The results obtained would be helpful in testing the recombinants as candidate immunogens against FMD and in achieving the objectives of the ongoing collaborative project between ICAR and USDA.

Besides, a pool of 7 capsid mutants ($VP2_{77}$, $VP2_{133}$, $VP3_{59}$, $VP3_{139}$, $VP1_{43\text{-}46,\ 48}$, $VP1_{168,\ 170,\ 171}$ and $VP1_{142\ \&\ 154}$) on hAd5-A IND 40/2000 capsid construct backbone were generated which would be further used to understand neutralization-relevant antigenic sites on capsid of type A viruses. To study the role of amino acid substitutions on the capsid of serotype A viruses in antigenicity and neutralization of virus infectivity, antigenically divergent field outbreak strain A IND 53/2008 (r1 value <0.2 with Indian vaccine strain A IND 40/2000) was selected. The deduced capsid (P1) amino acid sequence of A IND 53/2008 and A IND 40/2000 were aligned and the amino acid substitutions were tabulated. A heuristic approach was adopted to develop a scoring matrix for the individual amino acid substitutions, giving different weight to the parameters like surface accessibility, proximity to identified antigenic sites, secondary structural elements, unique nature of substitution and physico-chemical properties of the amino acids etc. which might be critical to make a site neutralization-relevant. Based on the final score obtained, the sites/substitutions were prioritized for mutagenesis.

9.0

National FMD Serosurveillance

9.1 DIVA (Antibody against NSPs; Percent Infected)

Seroconversion against non-structural proteins (NSPs) 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 test serum samples was assessed using purified recombinant 3AB3 (~38 kD) NSP in an indirect ELISA. The test is to be considered as 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 supplied 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. 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 39,882 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 in ~ 26.09% samples/animals (Table 9.1). The test also included serum samples from recent suspected outbreak areas.

Table 9.1 Result summary of r3AB3 NSP-ELISA on bovine (cattle and buffalo) serum samples (Regional center, Network Units and Central FMD labs)

Sl. No.	Place of origin	Host	Total serum samples tested	Total positive	%3AB3 reactors
1	Andaman & Nicobar	Bovine	147	14	09.52
2	Andhra Pradesh	Bovine	2200	536	24.30
3	Assam	Bovine	1900	606	31.89
4	Arunachal Pradesh	Bovine	408	142	34.80
5	Bihar	Bovine	2300	632	27.48
6	Gujarat	Bovine	2280	918	40.26
7	Haryana	Bovine	3870	322	8.320
8	Himachal Pradesh	Bovine	1174	76	06.47
9	J & K	Bovine	816	115	14.09
10	Karnataka	Bovine	3078	1789	58.00
11	Kerala	Bovine	1000	228	22.88
12	Lakshadweep	Bovine	155	91	58.70
13	Madhya Pradesh	Bovine	3144	868	27.60
14	Maharashtra	Bovine	1620	719	44.38
15	Manipur	Bovine	900	186	20.70
16	Meghalaya	Bovine	300	93	31.00
17	Mizoram	Bovine	880	240	27.27
18	Nagaland	Bovine	2023	323	15.96
19	Odisha	Bovine	2900	293	10.10
20	Pudhucherry	Bovine	53	20	38.00
21	Tamilnadu	Bovine	3000	863	29.00
22	Uttar Pradesh	Bovine	181	24	13.25
23	West Bengal	Bovine	721	231	32.03
24	Nagaland	Bovine	1967	177	16.58
25	Tripura	Bovine	448	49	10.93
26	Uttarakhand	Bovine	450	132	29.3
27	Rajasthan	Bovine	1967	723	36.8
	Total		39,882	10,409	26.09

Table 9.2 Summary of r3AB3 NSP-ELISA During 2008-09 to 2011-2012; the prevalence has been around 27%

Year	Total sample tested	States from which samples were collected	Total positive	% Diva reactors
2008-09	18,326	Tripura,Gujarat,Mizoram, Himachal Pradesh,Nagaland, Bihar,Madhya Pradesh, West Bengal,Manipur, Maharashtra,Punjab, Kerala,Andhra Pradesh, Arunachal Pradesh,Orissa, Haryana,Jammu & Kashmir, Rajasthan,Karnataka, Tamil Nadu	**5120**	27.94
2009-10	29,763	Tripura,Gujarat,Mizoram,Himachal Pradesh,Nagaland,Bihar,Madhya Pradesh, West Bengal,Manipur,Maharashtra,Punjab,Kerala,Andhra Pradesh,Arunachal Pradesh, Orissa,Haryana,Jammu & Kashmir, Rajasthan,Karnataka,Tamil Nadu,Assam	**8303**	27.9 %
2010-11	31,042	Assam,Manipur, Mizoram,Nagaland, Tripura,Haryana,Punjab,Orissa, Tamilnadu,Bihar,Andhra Pradesh,West Bengal, Himachal Pradesh, MP, Karnataka, Gujarat,J & K, UP,MP,Manipur,Kerala, Uttarakhand,Rajasthan, Arunachal Pradesh,Maharashtra	**8341**	26.87
2011-12	37,467	Andaman & Nicobar, Andhra Pradesh, Assam, Arunachal Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, J & K, Karnataka, Kerala, Lakshadweep,,Madhaya Pradesh,,Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Pudhucherry, Tamilnadu, UP,West Bengal, Rajasthan, Uttarakhand, Nagaland, Tripura	**10,410**	26.09
Total	1,17,598		**32,174**	27.35

9.2 LPB-ELISA (Percent protected)

During the year under report, a total of 22,089 serum samples were subjected to LPB ELISA for determination of antibody level against structural protein (SPs) of serotypes O, A and Asia1. The result showed protective antibody titre in 46.18%, 36.47% and 26.22 % samples/animals against serotypes O, A and Asia1, respectively (Table 9.3).

Table 9.3 Summary of LPBE result obtained on Random serum samples

Sl. No.	Name of place/State	Species	Total no. of samples	No. and % animals showing ≥ $\log_{10}$ 1.8 titer		
				O	A	Asia-1
1.	Andaman & Nicober	Cattle	112	22(19.64)	12(10.71)	9(08.04)
2.	Andhra Pradesh	Cattle+Buffalo	2273	1230(54.11)	981(43.16)	535(23.54)
3.	Arunachal Pradesh	Cattel+Mithun	588	315	325	250
4.	Assam	Cattle	73	1(01.37)	0(00.00)	0(00.00)
5.	Bihar	Cattle+ Buffalo	1299	444(34.18)	267(20.55)	168(12.93)
6.	Gujarat	Cattle	30	20(66.67)	13(43.33)	11(36.67)
7.	Himachal Pradesh	Cattle+ Buffalo	1174	710(60.48)	649(55.28)	588(50.09)
8.	Karnataka	Cattle+ Buffalo	3215	1637(50.92)	1268(39.44)	864(26.87)
9.	Kerala	Cattle	333	92(27.63)	60(18.02)	38(11.14)
10.	Jammu & Kashmir	Cattle+ Buffalo	1741	495(28.41)	366(21.02)	218(12.52)
11.	Madhya Pradesh	Cattle+ Buffalo	3135	489(15.60)	489(15.60)	406(12.95)
12.	Manipur	Cattle+ Buffalo	900	581(64.6)	561(62.3)	506(56.2)
13.	Mizoram	Cattle	273	107(39.14)	80(29.30)	14(05.12)
14.	Maharashtra	Cattle+ Buffalo	2118	1293(61.05)	1112(52.50)	703(33.19)
15.	Meghalaya	Cattle	100	19(19.00)	16(16.00)	5(05.00)
16.	Odisha	Cattle	79	42(53.16)	21(42.05)	18(35.23)

Sl. No.	Name of place/State	Species	Total no. of samples	No. and % animals showing ≥ $\log_{10}$ 1.8 titer		
				O	A	Asia-1
17.	Punjab	Cattle+ Buffalo	1000	699(69.9)	592(59.2)	664(66.4)
18.	Rajasthan	Cattle	88	47(53.41)	37(42.05)	31(35.23)
19.	Tamilnadu	Cattle	340	114(33.53)	58(17.06)	28(08.24)
20.	Uttarakhand	Cattle	388	166(42.78)	139(35.82)	98(25.26)
21.	Uttar Pradesh	Cattle	256	148(57.81)	130(50.78)	117(45.70)
22.	West Bengal	Bovine	644	205(31.83)	145(22.51)	60(09.31)
23.	IVRI (UK)	Cattle	249	36(14.46)	27(10.84)	18(07.23)
24	IVRI (UP)	Cattle	176	36(20.45)	12(06.82)	7(03.98)
25.	NDRI, Karnal	Cattle+ Buffalo	1486	1236(83.18)	685(46.10)	427(28.73)
26.	PDC, Meerut	Cattle	19	17(89.47)	12(63.16)	9(47.37)
	Total		22089	10201(46.18)	8057(36.47)	5792(26.22)

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

9.3 Surveillance and Monitoring of FMD in ovine, caprine and porcine species in India

A total of 3,449 serum samples were collected and tested by DIVA and LPBE of which 2052 samples were from sheep, 1216 from Goats and 181 from Pigs.

DIVA

Out of 1165 ovine serum samples tested in DIVA-ELISA, 349 (29.95%) samples/animals were found to be 3AB-NSP reactors and out of 1013 caprine serum samples tested, 127 (12.53%) samples/animals were found to be 3AB-NSP reactors.

LPB-ELISA

Sheep: A total of 1986 ovine serum samples were tested in LPB-ELISA. 209 (10.52%) samples showed log10 titer of 1.5 against serotype O, 187 (9.41%) against serotype A and 194 (9.76%) against serotype Asia 1. 146 (7.35%) samples showed log10 titer of 1.8 against serotype O, 147 (7.40%) against serotype A and 117 (5.89%) against serotype Asia 1. 319 (16.06%) samples showed log10 titer of >2.1 against serotype O, 142 (7.15%) against serotype A and 77 (3.87%) against serotype Asia 1.

Goat: A total of 921 caprine serum samples tested in LPB-ELISA. 105 (11.40%) samples showed log10 titer of 1.5 against serotype O, 59 (6.40%) against serotype A and 72 (7.81%) against serotype Asia 1. 68 (7.38%) samples showed log10 titer of 1.8 against serotype O, 73 (7.92%) against serotype A and 49 (5.32%) against serotype Asia 1.130 (14.11%) samples showed log10 titer of >2.1 against serotype O, 122 (13.24%) against serotype A and 64 (6.94%) against serotype Asia 1.

Pig: A total of 181 porcine serum samples tested in LPB-ELISA. 19 (10.49%) samples showed log10 titer of 1.5 against serotype O, 12 (6.62%) against serotype A and 7 (3.86%) against serotype Asia 1. 4 (2.20%) samples showed log10 titer of 1.8 against serotype O, 2 (1.10%) against serotype A and 0 (0%) against serotype Asia 1.4 (2.20%) samples showed log10 titer of >2.1 against serotype O, 0 (0%) against serotype A and 1 (0.55%) against serotype Asia 1.

Conclusion: From the above LPB-ELISA and 3AB-NSP-DIVA-ELISA, the evidence of FMD virus circulation among small ruminants and pig population of the country is clearly obtained. The protective titer of antibody to various serotypes also showed a great variation. Regular surveillance and monitoring of FMD in these species is required for the control and eradication of this economically important disease.

10.0

Post Vaccinal Seroconversion Studies

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 August 2003-04 covering 54 specified districts in the country. This involves 6 monthly vaccinations (trivalent; O, A and Asia1) 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 centres of PD-FMD for estimation of level of serotype specific neutralizing antibodies by Liquid Phase Blocking ELISA (LPBE) developed by PD-FMD. The Regional Centers, Network Units and Central FMD laboratory of the Project Directorate participate in this post vaccinal sero-conversion under FMD-CP. Since 2011-12, Central Agricultural Research Institute, Port Blair has been included as testing laboratory for sero-monitoring of FMD in A & N Islands. All reagent and training to conduct LPB ELISA are provided by the institute. The test was compared with SNT, and it is recommended that LPB ELISA titer (in serum) of $\geq \log_{10}$ 1.8 indicates protection against FMD. Due to initial success, additional 167 districts have been included under the programme in 2010-11. Currently, this programme includes 221 districts of the country covering states of the 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 and 16 districts in Uttar Pradesh (Fig 10.1), and targeting ~120 million cattle and buffalo.

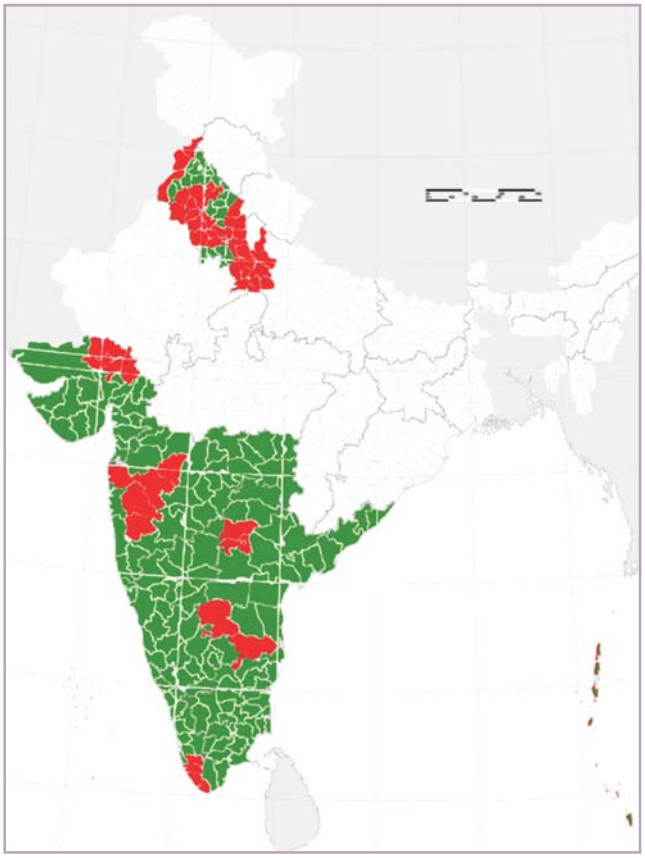


Fig 10.1. Region covered under FMD-CP. Fifty four districts in which control programme started in 2003-04 are marked red. One sixty seven districts in which the control programme started in 2010-11 are marked green.

During 2011-12, a total of 47,510 pre and post vaccinated serum samples were tested and of which, 24,970 serum samples were from first phase FMD CP districts representing XI, X, XI and XII phases of vaccinations and remaining 22,540 serum samples were from expanded FMD CP districts representing Phases, I and II.

10.1.1 Sero-monitoring in Andaman & Nicobar Island

Initially, eight villages of Andaman & Nicobar were covered under FMDCP in 2003-04 and later in 2010-11, whole Andaman & Nicobar Island was included. Central Agricultural Research Institute, Port Blair is undertaking the sero-monitoring of animals covered under the programme in A&N Islands

- No serum samples were received for phases I and II.

- In phase III, 154 pre and 162 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 25.9 for type 'O', 2.8 for type 'A' and 34.0 for type 'Asia 1'. The same for post-vac samples was 60.0 for type 'O', 20.3 for type 'A' and 73.6 for type 'Asia 1'.
- In phase IV, 149 pre and 146 post-vac serum samples were tested. Percent serum samples having protective antibody titer of 1.8 and above for pre-vac samples were 33.5 for type 'O', 33.5 for type 'A' and 23.4 for type 'Asia 1'. The same for post-vac samples were 64.6 for type 'O', 65.9 for type 'A' and 67.6 for type 'Asia 1'.
- In phase V, 126 pre and 122 post-vac serum samples were tested. Percent serum samples having protective antibody titer of 1.8 and above for pre-vac samples were 57.2 for type 'O', 50.8 for type 'A' and 44.3 for type 'Asia 1'. The same for post-vac samples were 55.8 for type 'O', 52.5 for type 'A' and 50.8 for type 'Asia 1'.
- In phase VI, 270 pre and 270 post-vac serum samples were tested. Percent serum samples having protective antibody titer of 1.8 and above for pre-vac samples were 18.5 for type 'O', 24.4 for type 'A' and 10.2 for type 'Asia 1'. The same for post-vac samples were 29.6 for type 'O', 38.4 for type 'A' and 13.2 for type 'Asia 1'.
- In phase VII, 265 pre and 265 post-vac serum samples were tested. Percent serum samples having protective antibody titer of 1.8 and above for pre-vac samples were 42.3 for type 'O', 30.9 for type 'A' and 21.1 for type 'Asia 1'. The same for post-vac samples were 65.7 for type 'O', 41.5 for type 'A' and 24.9 for type 'Asia 1'.
- In phase VIII, 251 pre and post-vac serum samples were tested. Percent serum samples having protective antibody titer of 1.8 and above for pre-vac samples were 21.11 for type 'O', 7.17 for type 'A' and 18.72 for type 'Asia 1'. The same for post-vac samples were 40.63 for type 'O', 19.52 for type 'A' and 33.86 for type 'Asia 1'.
- In phase IX, 228 pre and post-vac serum samples were tested. Percent serum samples having protective antibody titer of 1.8 and above for pre-vac samples were 32.01 for type 'O', 13.59 for type 'A' and 24.56 for type 'Asia 1'. The same for post-vac samples were 30.26 for type 'O', 15.35 for type 'A' and 18.82 for type 'Asia 1'.
- In phase XII, 180 each of pre and post-vac serum samples were tested. Percent serum samples having protective antibody titer of 1.8 and above for pre-vac samples were 20 for type 'O', 10.56 for type 'A' and 6.11 for type 'Asia 1'. The same for post-vac samples were 27.22 for type 'O', 22.22 for type 'A' and 16.67 for type 'Asia 1'.
- Overall, herd immunity and post vaccinal boosting is low in A & N Islands

Table 10.1 Result of seroconversion in Andaman & Nicobar Islands

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
III	Cattle+Buffalo	40(25.9)	97(60.0)	5(2.8)	37(20.3)	52(34.0)	118(73.6)
IV	Cattle+Buffalo	50(33.5)	94(64.6)	50(33.5)	96(65.9)	35(23.4)	101(67.6)
V	Cattle+Buffalo	72(57.2)	68(55.8)	62(50.8)	64(52.5)	54(44.3)	62(50.8)
VI	Cattle+Buffalo	50 (18.5)	80 (29.6)	66 (24.4)	104 (38.4)	28 (10.2)	36 (13.2)
VII	Cattle+Buffalo	112 (42.3)	174 (65.7)	82 (30.9)	110 (41.5)	56 (21.1)	66 (24.9)
VIII	Cattle+Buffalo	53(21.11)	102(40.63)	18(7.17)	49(19.52)	47(18.72)	85(33.86)
IX	Cattle+Buffalo	73(32.01)	69(30.26)	31(13.59)	35(15.35)	56(24.56)	42(18.42)
XII	Cattle+Buffalo	36(20.0)	49(27.22)	19(10.56)	40(22.22)	11(6.11)	30(16.67)

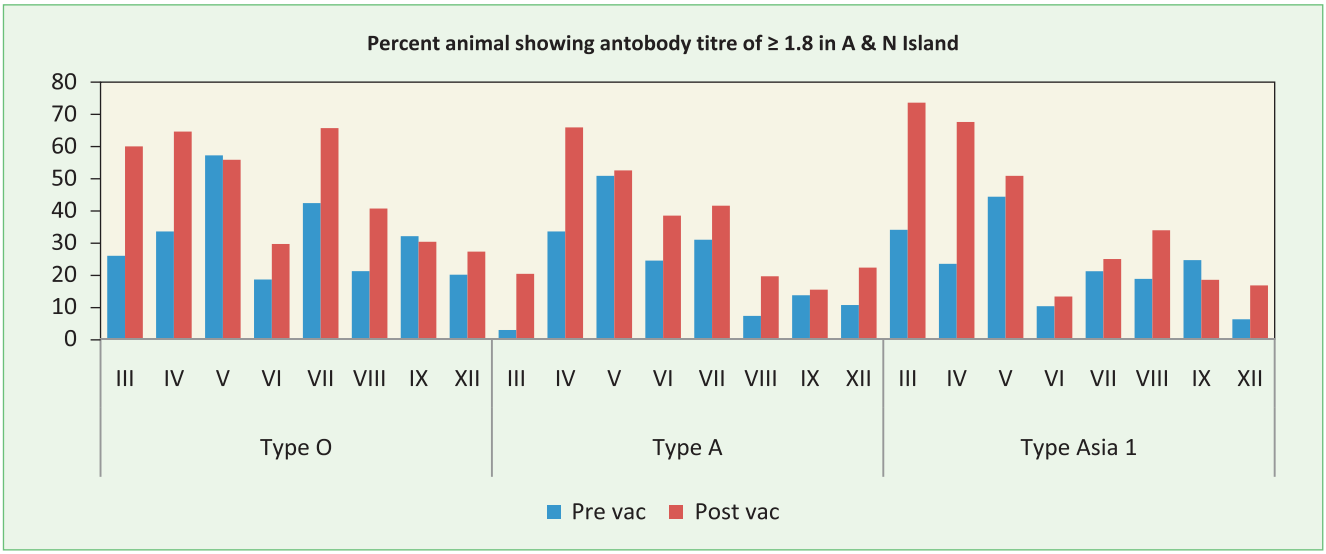


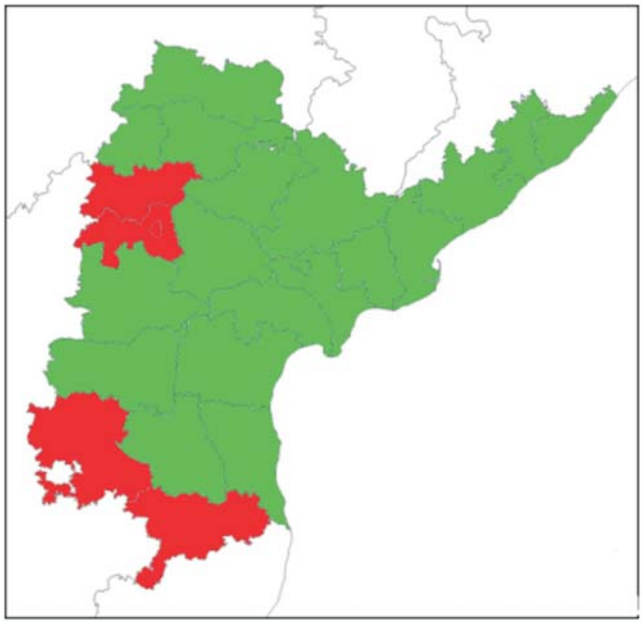
Fig 10.2 Seroconversion in Andaman & Nicobar

10.1.2 Sero-monitoring in Andhra Pradesh

Four districts of Andhra Pradesh namely, Ananthapur, Chitoor, Medak and Rangareddy are covered under FMDCP in 2003-04 (filled red) and rest of the districts (filled green) were included in 2010-11.

Districts included in 2003-04

- In phase I, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 10.3 for type 'O', 5.3 for type 'A' and 11.5 for type 'Asia 1'. The same for post-vac samples was 42.5 for type 'O', 30.5 for type 'A' and 42.5 for type 'Asia 1'. It shows boosting of antibody level following vaccination.



- In phase II, 800 post-vac serum samples were tested. Pre-vac serum samples were not available. Percent serum sample having protective antibody titer of 1.8 and above was 54.2 for type 'O', 62.3 for type 'A' and 54.7 for type 'Asia 1'.
- In phase III, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 26.2 for type 'O', 49.3 for type 'A' and 38.2 for type 'Asia 1'. The same for post-vac samples was 35.7 for type 'O', 66.5 for type 'A' and 52.7 for type 'Asia 1'.
- In phase IV, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 35.1 for type 'O', 58.1 for type 'A' and 41.1 for type 'Asia 1'. The same for post-vac samples was 46.8 for type 'O', 77.1 for type 'A' and 64.8 for type 'Asia 1'.
- In phase V, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 30.8 for type 'O', 58.2 for type 'A' and 42.8 for type 'Asia 1'. The same for post-vac

samples was 55.0 for type 'O', 71.8 for type 'A' and 56.3 for type 'Asia 1'.

- In phase VI, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 34.3 for type 'O', 69.2 for type 'A' and 55.7 for type 'Asia 1'. The same for post-vac samples was 61.3 for type 'O', 86.3 for type 'A' and 79.3 for type 'Asia 1'.
- In phase VII, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 34.0 for type 'O', 44.0 for type 'A' and 48.8 for type 'Asia 1'. The same for post-vac samples was 60.3 for type 'O', 67.5 for type 'A' and 64.7 for type 'Asia 1'.
- In phase VIII, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 44.5 for type 'O', 51.8 for type 'A' and 41.6 for type 'Asia 1'. The same for post-vac samples was 74.0 for type 'O', 78.0 for type 'A' and 65.8 for type 'Asia 1'.
- In phase IX, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 52.8 for type 'O', 41.1 for type 'A' and 35.9 for type 'Asia 1'. The same for post-vac samples was 84.1 for type 'O', 66.8 for type 'A' and 66.8 for type 'Asia 1'.
- In phase X, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 62.7 for type 'O', 46 for type 'A' and 51.3 for type 'Asia 1'. The same for post-vac samples was 79.3 for type 'O', 71.8 for type 'A' and 75.2 for type 'Asia 1'.
- In phase XI, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 49.75 for serotype O, 44.5 for serotype A and 41.62 for serotype Asia 1. The same for post-vac samples was 77.12 for type O, 75 for type A and 71.5 for serotype Asia 1.
- In phase XII, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 48.37 for serotype O, 33.25 for serotype A and 22.12 for serotype Asia 1. The same for post-vac samples was 71 for type O, 60.37 for type A and 45.87 for serotype Asia 1.
- Overall post-vac response is >60% for serotype O and serotype A.

Table 10.2 Result of seroconversion in Andhra Pradesh

Phase	Species	Number & % animals showing titres ≥ 1.8 $\log_{10}$ against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	83 (10.3)	340 (42.5)	43 (5.3)	244 (30.5)	92 (11.5)	340 (42.5)
II	Cattle+Buffalo	N.A.	434 (54.2)	N.A.	498 (62.3)	N.A.	438 (54.7)
III	Cattle+Buffalo	210 (26.2)	286 (35.7)	395 (49.3)	532 (66.5)	306 (38.2)	422 (52.7)
IV	Cattle+Buffalo	281 (35.1)	374 (46.8)	465 (58.1)	617 (77.1)	329 (41.1)	518 (64.8)
V	Cattle+Buffalo	247 (30.8)	440 (55)	466 (58.2)	574 (71.8)	343 (42.8)	450 (56.3)
VI	Cattle+Buffalo	275 (34.3)	490 (61.3)	554 (69.2)	690 (86.3)	446 (55.7)	634 (79.3)
VII	Cattle+Buffalo	274 (34.0)	483 (60.3)	349 (44.0)	540 (67.5)	391 (48.8)	518 (64.7)
VIII	Cattle+Buffalo	356 (44.5)	594 (74.0)	415 (51.8)	624 (78.0)	333 (41.6)	527 (65.8)
IX	Cattle+Buffalo	422 (52.8)	673 (84.1)	329 (41.1)	534 (66.8)	287 (35.9)	534 (66.8)
X	Cattle+Buffalo	502(62.7)	635(79.3)	368(46)	575(71.8)	411(51.3)	602(75.2)
XI	Cattle+Buffalo	398(49.75)	617(77.12)	356(44.5)	600(75)	333(41.62)	568(71.5)
XII	Cattle+Buffalo	387(48.37)	568(71)	266(33.25)	483(60.37)	177(22.12)	367(45.87)

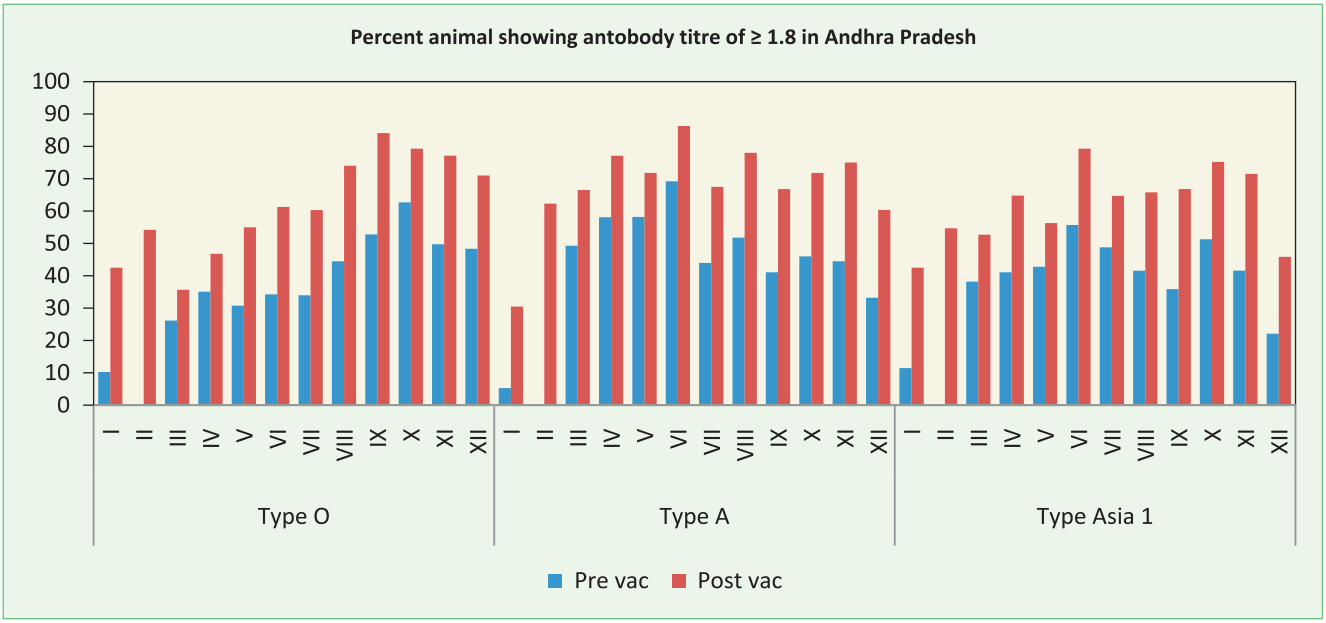


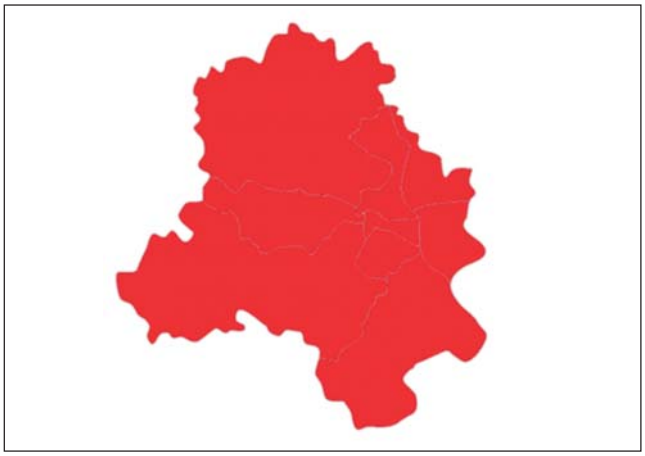
Fig 10.3 Seroconversion in Andhra Pradesh

Districts included in 2010-11

- In phase I, 3600 each of pre and post-vac serum samples from 18 districts were tested. Percent serum samples having protective antibody titer of 1.8 and above for pre-vac samples was 28.97 for serotype O, 18 for serotype A and 13.09 for serotype Asia 1. The same for post-vac samples was 66.55 for type O, 56.38 for type A and 47.47 for serotype Asia 1. It shows boosting of antibody level following vaccination.
- In phase II, 1600 each of pre and post-vac serum samples from 8 districts were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 40.68 for serotype O, 28.23 for serotype A and 14.81 for serotype Asia 1. The same for post-vac samples was 73.12 for type O, 66.68 for type A and 49.18 for serotype Asia 1.
- Overall post-vac response is >60% for serotype O and serotype A

10.1.3 Sero-monitoring in Delhi

Delhi was included under FMDCP in 2003-04.



Districts included in 2003-04

- In phase I, 50 each of pre and post-vac serum samples from buffaloes were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 53 for type 'O', 26 for type 'A' and 34 for type 'Asia 1'. The same for

Table 10.3 Result of seroconversion in Andhra Pradesh

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	1043(28.97)	2396(66.55)	648(18)	2030(56.38)	419(13.09)	1709(47.47)
II	Cattle+Buffalo	651(40.68)	1170(73.12)	455(28.33)	1067(66.68)	237(14.81)	787(49.18)

post-vac samples was 100 for type 'O', 94 for type 'A' and 96 for type 'Asia 1'.

- In phase II, 24 each of pre-vac and post-vac serum samples from buffaloes were tested. Pre-vac serum samples were not available. Percent serum sample having protective antibody titer of 1.8 and above was 91 for type 'O', 40 for type 'A' and 95 for type 'Asia 1'. The same for post-vac samples was 96 for type 'O', 62 for type 'A' and 86 for type 'Asia 1'.
- In phase III, 50 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 94 for type 'O', 60 for type 'A' and 86 for type 'Asia 1'. The same for post-vac samples was 98 for type 'O', 80 for type 'A' and 92 for type 'Asia 1'.
- In phase IV, 50 pre and 46 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 76 for type 'O', 28 for type 'A' and 54 for type 'Asia 1'. The same for post-vac samples was 82.6 for type 'O', 86.9 for type 'A' and 89.1 for type 'Asia 1'.
- In phase V, 44 pre and 53 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 59 for type 'O', 52.2 for type 'A' and 72.7 for type 'Asia 1'. The same for post-vac samples was 88.6 for type 'O', 69.8 for type 'A' and 77.3 for type 'Asia 1'.
- In phase VI, 98 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 77.5 for type 'O', 61.2 for type 'A' and 72.4 for type 'Asia 1'. The same for post-vac samples was 98.9 for type 'O', 94.9 for type 'A' and 98.9 for type 'Asia 1'.
- In phase VII, 50 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 78 for type 'O', 66 for type 'A' and 50 for type 'Asia 1'. The same for post-vac samples was 88 for type 'O', 86 for type 'A' and 82 for type 'Asia 1'.
- In phase VIII, 100 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 92 for type 'O', 66 for type 'A' and 83 for type 'Asia 1'. The same for post-vac samples was 100 for type 'O', 86 for type 'A' and 98 for type 'Asia 1'.
- In phase IX, 100 pre-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 57 for type 'O', 65 for type 'A' and 33 for type 'Asia 1'. Post-vac serum samples were not available.
- In phase X, serum samples were not made available for testing.
- In phase XI, 200 pre-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 86 for type 'O', 50 for type 'A' and 45.5 for type 'Asia 1'.

Table 10.4 Result of seroconversion in Delhi

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Buffalo	26 (53)	50 (100)	13 (26)	47 (94)	17 (34)	48 (96)
II	Buffalo	22 (91)	23 (96)	12 (40)	15 (62)	23 (95)	22 (86)
III	Cattle+Buffalo	47 (94)	49 (98)	30 (60)	40 (80)	43 (86)	46 (92)
IV	Cattle+Buffalo	38 (76)	38 (82.6)	14 (28)	40 (86.9)	27 (54)	41 (89.1)
V	Cattle+Buffalo	26 (59)	47 (88.6)	23 (52.2)	37 (69.8)	32 (72.7)	41 (77.3)
VI	Cattle+Buffalo	76 (77.5)	97 (98.9)	60 (61.2)	93 (94.9)	71 (72.4)	97 (98.9)
VII	Cattle+Buffalo	39(78)	44(88)	33(66)	43(86)	25(50)	41(82)
VIII	Cattle+Buffalo	92 (92)	100 (100)	66 (66)	86 (86)	83 (83)	98 (98)
IX	Cattle+Buffalo	57(57)	NA	65(65)	NA	33(33)	NA
XI	Buffalo	172(86)	NA	100(50)	NA	91(45.5)	NA

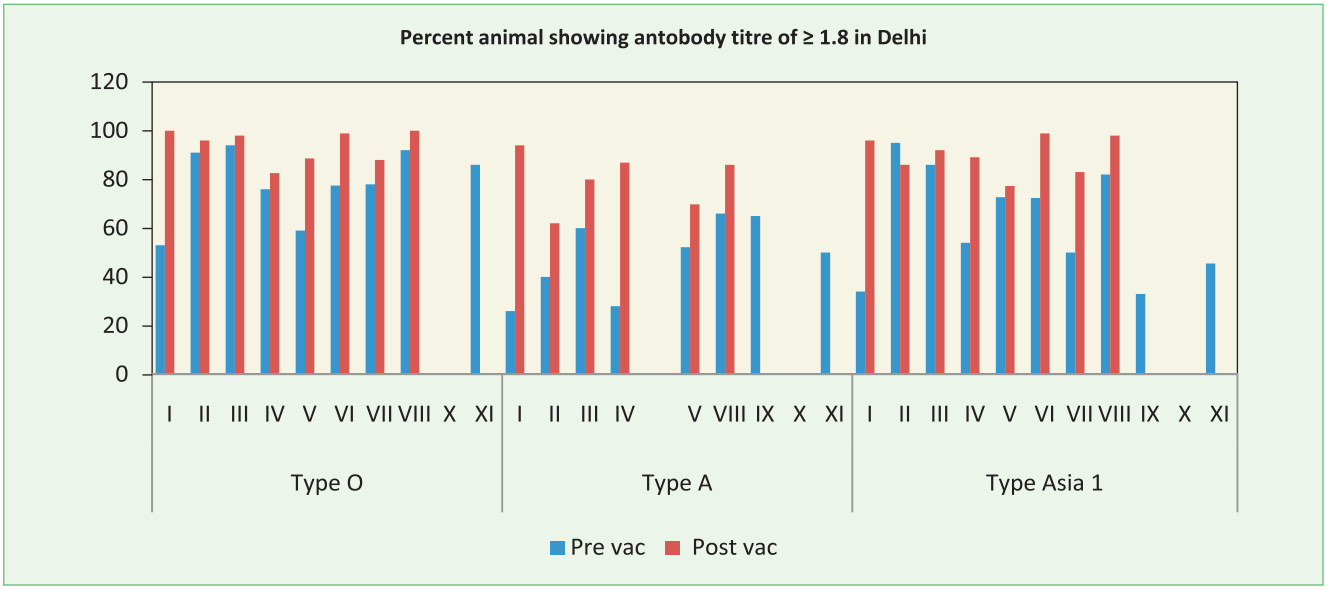


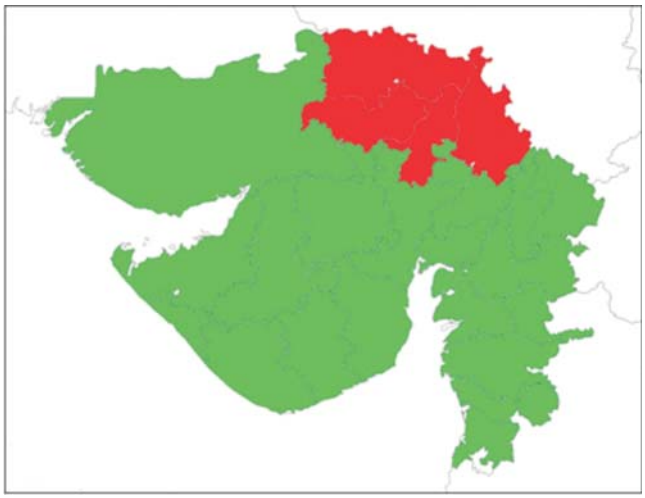
Fig 10.4 Seroconversion in Delhi

10.1.4 Sero-monitoring in Gujarat

Four districts of Gujarat namely, Banaskantha, Sabarkantha, Mehsana and Patan were covered under FMDCP in 2003-04 (filled red) and later in 2010-11; rest of the districts (filled green) were included :

Districts included in 2003-04

- In phase I, 382 pre and 259 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 19.1 for type 'O', 24.5 for type 'A' and 16.1 for type 'Asia 1'. The same for post-vac samples was 44.7 for type 'O', 48.7 for type 'A' and 43.5 for type 'Asia 1'.



- Serum samples were not available for Phase II.
- In phase III, 442 pre and 357 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 27.8 for type 'O', 39.2 for type 'A' and 12.4 for type 'Asia 1'. The same for post-vac samples was 47.9 for type 'O', 58.3 for type 'A' and 35.4 for type 'Asia 1'.
- In phase IV, 497 and 456 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 22.7 for type 'O', 40.7 for type 'A' and 14.6 for type 'Asia 1'. The same for post-vac samples was 60.7 for type 'O', 81.2 for type 'A' and 46.8 for type 'Asia 1'.
- In phase V, 195 pre and 202 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 23.6 for type 'O', 66.1 for type 'A' and 26.5 for type 'Asia 1'. The same for post-vac samples was 49 for type 'O', 91.6 for type 'A' and 51.3 for type 'Asia 1'.
- In phase VI, 395 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 30.1 for type 'O', 63.0 for type 'A' and 49.3 for type 'Asia 1'. The same for post-vac

samples was 56.4 for type 'O', 80.2 for type 'A' and 60.7 for type 'Asia 1'.

- In phase VII, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 54.3 for type 'O', 48.1 for type 'A' and 43 for type 'Asia 1'. The same for post-vac samples was 78.8 for type 'O', 69.9 for type 'A' and 69.5 for type 'Asia 1'.
- In phase VIII, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 23.9 for type 'O', 24.6 for type 'A' and 33 for type 'Asia 1'. The same for post-vac samples was 49.3 for type 'O', 44.6 for type 'A' and 50.4 for type 'Asia 1'.
- In phase IX, 800 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 28.7 for type 'O', 35.5 for type 'A' and 40.7 for type 'Asia 1'. The same for post-vac samples was 77.2 for type 'O', 71.5 for type 'A' and 74.4 for type 'Asia 1'.
- In phase X, 800 each of pre and post-vac serum

Table 10.5 Result of seroconversion in Gujarat

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	50 (19.1)	116 (44.7)	59 (24.5)	128 (48.7)	42 (16.1)	114 (43.5)
II	Cattle+Buffalo	Serum samples not available					
III	Cattle+Buffalo	123 (27.8)	171 (47.9)	171 (39.2)	268 (58.3)	51 (12.4)	149 (35.4)
IV	Cattle+Buffalo	113 (22.7)	277 (60.7)	184 (40.7)	355 (81.2)	73 (14.6)	218 (46.8)
V	Cattle+Buffalo	46 (23.6)	99 (49.0)	126 (66.1)	179 (91.6)	44 (26.5)	92 (51.3)
VI	Cattle+Buffalo	119 (30.1)	223 (56.4)	249 (63.0)	317(80.2)	195 (49.3)	240 (60.7)
VII	Cattle+Buffalo	434 (54.3)	630 (78.8)	385 (48.1)	559 (69.9)	344 (43.0)	556 (69.5)
VIII	Cattle+Buffalo	191 (23.9)	394 (49.3)	197 (24.6)	357 (44.6)	264 (33.0)	403 (50.4)
IX	Cattle+Buffalo	230(28.7)	618(77.2)	284(35.5)	572(71.5)	326(40.7)	595(74.4)
X	Cattle+Buffalo	356(44.5)	620(77.5)	286(35.7)	525(65.6)	276(34.5)	535(66.9)
XI	Cattle+Buffalo	55(27.5)	76(38)	44(22)	71(35.5)	29(14.5)	49(24.5)
XII	Cattle+Buffalo	104(52)	105(52.5)	80(40)	67(33.5)	56(28)	25(12.5)

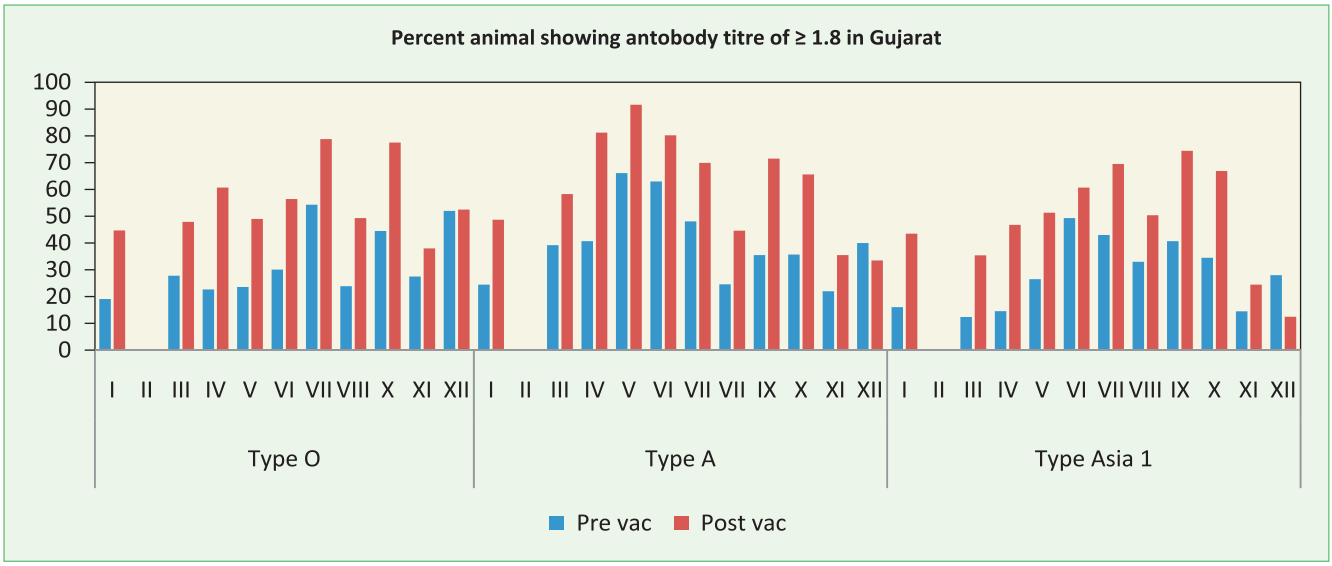


Fig 10.5 Seroconversion in Gujarat

samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 44.5 for type 'O', 35.7 for type 'A' and 34.5 for type 'Asia 1'. The same for post-vac samples was 77.5 for type 'O', 65.6 for type 'A' and 66.9 for type 'Asia 1'.

- In phase XI, 200 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 27.5 for serotype O, 22 for serotype A and 14.5 for serotype Asia 1. The same for post-vac samples was 38 for type O, 35.5 for type A and 24.5 for serotype Asia 1.
- In phase XII, 200 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 52 for serotype O, 40 for serotype A and 28 for serotype Asia 1. The same for post-vac samples was 52.5 for type O, 33.5 for type A and 12.5 for serotype Asia 1.
- Overall herd immunity is moderate.

10.1.5 Sero-monitoring in Haryana

Eight districts of Haryana namely, Bhiwani, Fatehabad, Hisar, Jhajjar, Jind, Rohtak, Sirsa and Sonipat were covered under FMDCP in 2003-04 (filled red) and later in 2010-11, rest of the districts (filled green) were included

Districts included in 2003-04

- Serum samples were not made available for Phase I.
- In phase II, 1558 post-vac serum samples were tested. Pre-vac serum samples were not available. Percent serum sample having protective antibody titer of 1.8 and above was 68.3 for type 'O', 55.1 for type 'A' and 53.3 for type 'Asia 1'.
- In phase III, 1585 post-vac serum samples were tested. Pre-vac serum samples were not available. Percent serum sample having protective antibody titer of 1.8 and above was 72.3 for type 'O', 63.6 for type 'A' and 63.4 for type 'Asia 1'.
- In phase IV, 1589 pre and 1552 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 60.1 for type 'O', 42.1 for type 'A' and 53.2 for type 'Asia 1'. The same for post-vac samples was 78.7 for type 'O', 57.1 for type 'A' and 75.3 for type 'Asia 1'.
- In phase V, 1600 pre and 1599 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 59.7 for type 'O', 50.8 for type 'A' and 58.8 for type 'Asia 1'. The same for post-vac samples was 84.5 for type 'O', 79.6 for type 'A' and 84.5 for type 'Asia 1'.
- In phase VI, 1496 pre and 1499 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 66.5 for type 'O', 59.8 for type 'A' and 56.4 for type 'Asia 1'. The same for post-vac samples was 87.1 for type 'O', 82 for type 'A' and 74.6 for type 'Asia 1'.
- In phase VII, 1562 pre and 1574 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 54.8 for type 'O', 65.3 for type 'A' and 56.8 for type 'Asia 1'. The same for post-vac samples was 82.3 for type 'O', 87.6 for type 'A' and 83.6 for type 'Asia 1'.

Table 10.6 Result of seroconversion in Haryana

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	Serum samples not available					
II	Cattle+Buffalo	NA	1065(68.3)	NA	859 (55.1)	NA	831 (53.3)
III	Cattle+Buffalo	NA	1146(72.3)	NA	1007(63.6)	NA	1005(63.4)
IV	Cattle+Buffalo	953 (60.1)	1222(78.7)	668 (42.1)	887 (57.1)	844(53.2)	1170(75.3)
V	Cattle+Buffalo	955 (59.7)	1352(84.5)	813 (50.8)	1274(79.6)	941(58.8)	1353(84.5)
VI	Cattle+Buffalo	995 (66.5)	1306(87.1)	895 (59.8)	1229(82.0)	844(56.4)	1118(74.6)
VII	Cattle+Buffalo	856(54.8)	1296 (82.3)	1021 (65.3)	1380 (87.6)	888 (56.8)	1317 (83.6)
VIII	Cattle+Buffalo	949(61.3)	1289 (83.7)	877 (56.6)	992 (64.4)	765 (49.4)	1101 (71.4)
IX	Cattle+Buffalo	647(43.2)	1140(77.2)	590(39.4)	1022(69.2)	410(27.4)	879(59.6)
X	Cattle+Buffalo	851(59.9)	1350(93.8)	615(43.3)	1003(69.7)	587(41.3)	1145(79.5)
XI	Cattle+Buffalo	734(48.9)	1302(88.9)	546(36.4)	1180(80.6)	455(30.3)	1109(75.8)
XII	Cattle+Buffalo	593(43.6)	975(80.6)	520(38.2)	989(81.7)	474(34.9)	896(74.1)

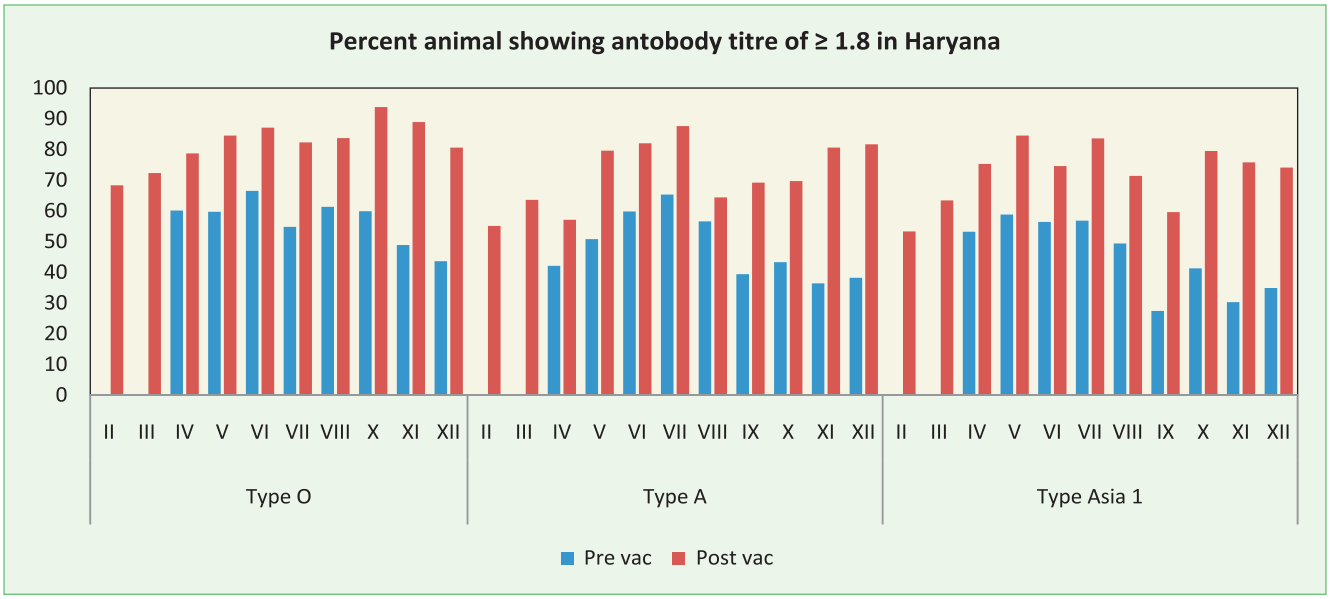


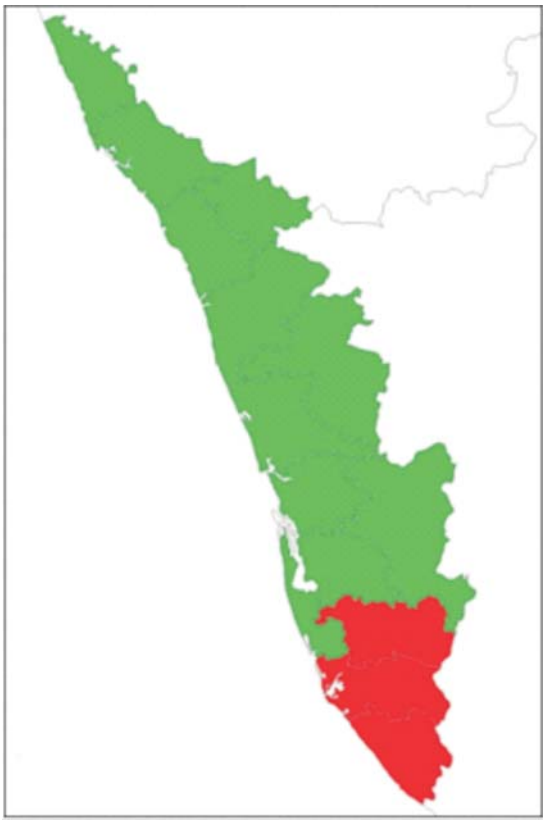
Fig 10.6 Seroconversion in Haryana

- In phase VIII, 1547 pre and 1540 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 61.3 for type 'O', 56.6 for type 'A' and 49.4 for type 'Asia 1'. The same for post-vac samples was 83.7 for type 'O', 64.4 for type 'A' and 71.4 for type 'Asia 1'.
- In phase IX, 1497 pre and 1476 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 43.2 for type 'O', 39.4 for type 'A' and 27.4 for type 'Asia 1'. The same for post-vac samples was 77.2 for type 'O', 69.2 for type 'A' and 59.6 for type 'Asia 1'.
- In phase X, 1420 pre and 1439 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 59.9 for type 'O', 43.3 for type 'A' and 41.3 for type 'Asia 1'. The same for post-vac samples was 93.8 for type 'O', 69.7 for type 'A' and 79.5 for type 'Asia 1'.

- In phase XI, 1500 pre and 1464 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 48.9 for serotype O, 36.4 for serotype A and 30.3 for serotype Asia 1. The same for post-vac samples was 88.9 for type O, 80.6 for type A and 75.8 for serotype Asia 1.
- In phase XII, 1360 pre and1210 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 43.6 for serotype O, 38.2 for serotype A and 34.9 for serotype Asia 1. The same for post-vac samples was 80.6 for type O, 81.7 for type A and 74.1 for serotype Asia 1.
- Overall post-vac response is very good at 77% against all the three serotypes, and this has been well reflected as drastic reduction in occurrence of the disease.

10.1.6 Sero-monitoring in Kerala

Three districts of Kerala namely, Trivandrum, Kollam and Pathanamthitta were covered under FMDCP in 2003-04 (filled red) and later in 2010-11, rest of the districts (filled green) were included:



- In phase I, II & IV, 483 pre and 496 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 32.7 for type 'O', 29 for type 'A' and 34.2 for type 'Asia 1'. The same for post-vac samples was 51.4 for type 'O', 47.5 for type 'A' and 56.4 for type 'Asia 1'.
- For phase III, serum samples were not available.
- In phase V, each of 290 pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 23.1 for type 'O', 17.9 for type 'A' and 21 for type 'Asia 1'. The same for post-vac samples was 67.9 for type 'O', 58.9 for type 'A' and 72.7 for type 'Asia 1'.
- In phase VI, each of 70 pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 20.4 for type 'O', 17.1 for type 'A' and 15.8 for type 'Asia 1'. The same for post-vac samples was 77.1 for type 'O', 70.4 for type 'A' and 71.3 for type 'Asia 1'.
- In phase VII, each of 300 pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 16.0 for type 'O', 14.3 for type 'A' and 17.3 for type 'Asia 1'. The same for post-vac samples was 69.3 for type 'O', 71.0 for type 'A' and 70.0 for type 'Asia 1'.
- In phase VIII & IX 600 pre and 600 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 37.6 for type 'O', 44.16 for type 'A' and 43.3 for type 'Asia 1'. The same for post-vac samples was 65.8 for type 'O', 56.8 for type 'A' and 66.2 for type 'Asia 1'
- In phase X, each of 400 pre and 100 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 40.0 for type 'O', 36.25 for type 'A' and 37.5 for type 'Asia 1'. The same for post-vac samples was 59 for type 'O', 66 for type 'A' and 53 for type 'Asia 1'.
- In phase XI, 352 pre and 315 post-vac serum samples from 2 districts were tested. Percent serum sample having protective antibody titer of

Table 10.7 Result of seroconversion in Kerala

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I & II & IV	Cattle+Buffalo	158(32.7)	255(51.4)	140(29.0)	236(47.5)	165(34.2)	280(56.4)
V	Cattle+Buffalo	67(23.1)	197(67.9)	52(17.9)	171(58.9)	61(21.0)	211(72.7)
VI	Cattle+Buffalo	49 (20.4)	185(77.1)	41(17.1)	169(70.4)	38(15.8)	171(71.3)
VII	Cattle+Buffalo	48 (16.0)	208(69.3)	43 (14.3)	213 (71.0)	52 (17.3)	210(70.0)
VIII & IX	Cattle+Buffalo	226(37.6)	395(65.8)	265(44.16)	341(56.8)	260(43.3)	397(66.2)
X	Cattle+Buffalo	160(40)	59(59)	145(36.25)	66(66)	150(37.5)	53(53)
XI	Cattle+Buffalo	122(18.29)	122(18.29)	122(18.29)	115(17.24)	96(14.39)	88(13.19)

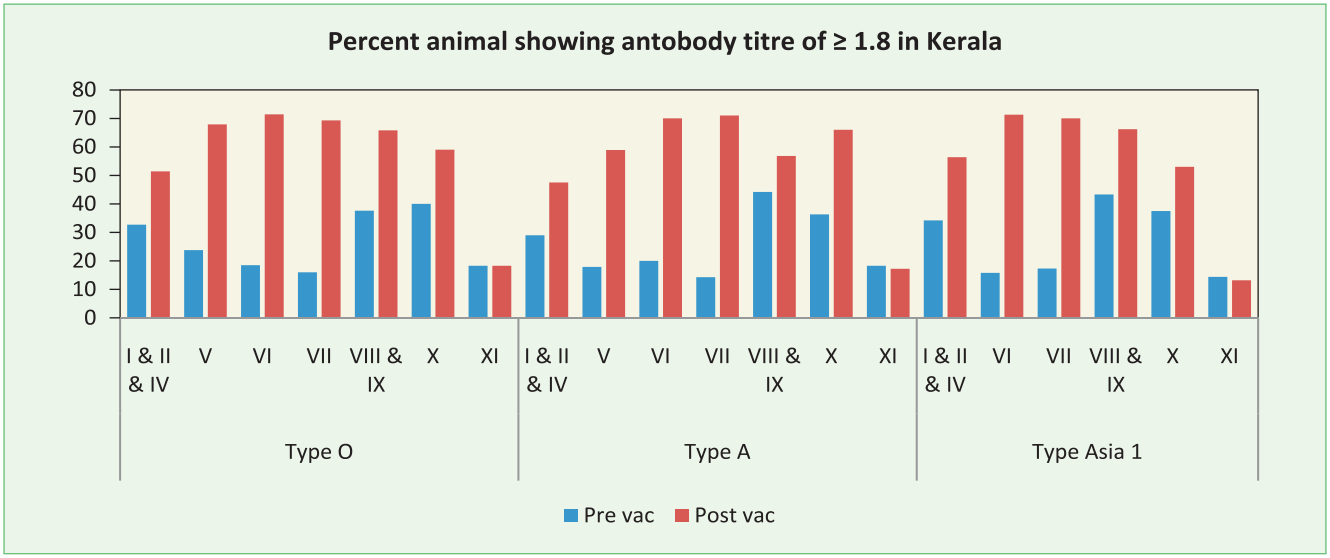


Fig 10.7 Seroconversion in Kerala

1.8 and above for pre-vac samples was 18.29 for serotype O, 18.29 for serotype A and 14.39 for serotype Asia 1. The same for post-vac samples was 18.29 for type O, 17.24 for type A and 13.19 for serotype Asia 1.

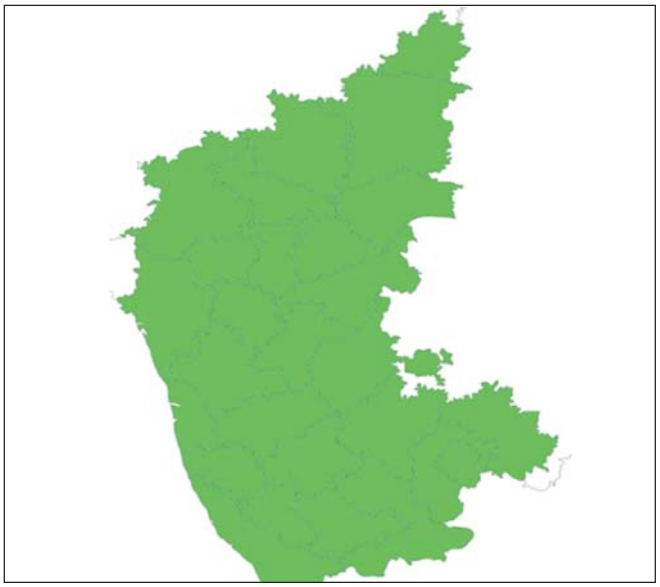
- Herd immunity is very poor against all the three serotypes

10.1.7 Sero-monitoring in Karnataka

State of Karnataka was included under FMDCP in 2010-11

Districts included in 2010-11

- In phase I, 645 pre and 396 post-vac serum samples from 4 districts were tested. Percent serum



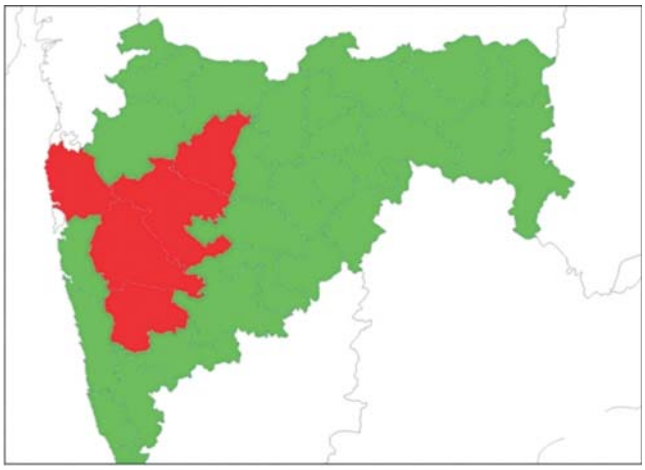
Phase	Species	Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	270(42)	344(87)	155(24)	279(70)	74(11)	224(57)

samples having protective antibody titer of 1.8 and above for pre-vac samples was 42 for serotype O, 24 for serotype A and 11 for serotype Asia 1. The same for post-vac samples was 87 for type O, 70 for type A and 57 for serotype Asia 1.

- There is clear boosting effect after first vaccination, and resulting herd immunity of >55% is a good indicator.

10.1.8 Sero-monitoring in Maharashtra

Six districts of Maharashtra namely, Ahmadnagar, Aurangabad, Pune, Satara, Mumbai and Thane were covered under FMDCP in 2003-04 (filled red) and later in 2010-11, rest of the districts (filled green) were included:



Districts included in 2003-04

- In phase I, 844 pre and 761 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 20.5 for type 'O', 17.9 for type 'A' and 22.8 for type 'Asia 1'. The same for post-vac samples was 59.9 for type 'O', 57.4 for type 'A' and 61.2 for type 'Asia 1'.
- In phase II, 834 post-vac serum samples were tested. Pre-vac serum samples were not available. Percent serum sample having protective antibody titer of 1.8 and above was 60.9 for type 'O', 58.6 for type 'A' and 66.2 for type 'Asia 1'.
- In phase III, 753 pre and 799 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 34.4 for type 'O', 46.8 for type 'A' and 34.7 for type 'Asia 1'. The same for post-vac samples was 54.8 for type 'O', 72.7 for type 'A' and 66.9 for type 'Asia 1'.
- In phase IV, 789 and 797 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 24.2 for type 'O', 65.6 for type 'A' and 35.2 for type 'Asia 1'. The same for post-vac samples was 52.3 for type 'O', 85.3 for type 'A' and 63.9 for type 'Asia 1'.
- In phase V, 802 pre and 772 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 17.7 for type 'O', 44.2 for type 'A' and 15 for type 'Asia 1'. The same for post-vac samples was 35.1 for type 'O', 62.3 for type 'A' and 31.8 for type 'Asia 1'.
- In phase VI, 901 pre and 928 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 44.9 for type 'O', 69 for type 'A' and 27.2 for type 'Asia 1'. The same for post-vac samples was 71.4 for type 'O', 91.9 for type 'A' and 48.1 for type 'Asia 1'.
- In phase VII, 1000 pre and 1000 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 44.6 for type 'O', 70.1 for type 'A' and 43.1 for type 'Asia 1'. The same for post-vac samples was 69.2 for type 'O', 89.3 for type 'A' and 66.7 for type 'Asia 1'.
- In phase VIII, 1000 pre and 1000 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 64.6 for type 'O', 57.4 for type 'A' and 19.8 for type 'Asia 1'. The same for post-vac

samples was 90.4 for type 'O', 84.8 for type 'A' and 45.2 for type 'Asia 1'.

- In phase IX, 1000 pre and 1000 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 73 for type 'O', 52.4 for type 'A' and 32.4 for type 'Asia 1'. The same for post-vac samples was 95.1 for type 'O', 51.7 for type 'A' and 69.5 for type 'Asia 1'.
- In phase X, 1000 pre and 1000 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 78.5 for type 'O', 68.6 for type 'A' and 60.7 for type 'Asia 1'. The same for post-vac samples was 97.8 for type 'O', 93.5 for type 'A' and 84.6 for type 'Asia 1'.
- In phase XI, 1000 pre and 1000 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 55.8 for serotype O, 53.4 for serotype A and 40.3 for serotype Asia 1. The same for post-vac samples was 91.6 for type O, 87.1 for type A and 83.7 for serotype Asia 1.

Table 10.8 Result of seroconversion in Maharashtra

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	173 (20.5)	456 (59.9)	151(17.9)	437 (57.4)	192 (22.8)	466 (61.2)
II	Cattle+Buffalo	N.A.	508 (60.9)	N.A.	490 (58.6)	N.A.	553 (66.2)
III	Cattle+Buffalo	184 (24.4)	438 (54.8)	351 (46.8)	580 (72.7)	262 (34.7)	534 (66.9)
IV	Cattle+Buffalo	191 (24.2)	417 (52.3)	517 (65.6)	679 (85.3)	278 (35.2)	509 (63.9)
V	Cattle+Buffalo	142 (17.7)	271 (35.1)	353 (44.2)	477 (62.3)	121 (15.0)	245 (31.8)
VI	Cattle+Buffalo	404 (44.9)	663 (71.4)	622 (69)	853 (91.9)	245 (27.2)	446 (48.1)
VII	Cattle+Buffalo	446 (44.6)	692 (69.2)	701 (70.1)	893 (89.3)	431 (43.1)	667 (66.7)
VIII	Cattle+Buffalo	646 (64.6)	904 (90.4)	574 (57.4)	848 (84.8)	198 (19.8)	452 (45.2)
IX	Cattle+Buffalo	730(73)	951(95.1)	524(52.4)	817(81.7)	324(32.4)	695(69.5)
X	Cattle+Buffalo	785(78.5)	978(97.8)	686(68.6)	935(93.5)	607(60.7)	846(84.6)
XI	Cattle+Buffalo	558(55.8)	916(91.6)	534(53.4)	871(87.1)	403(40.3)	837(83.7)
XII	Cattle+Buffalo	590(60.2)	894(91.2)	468(47.75)	823(83.97)	341(34.79)	730(74.48)

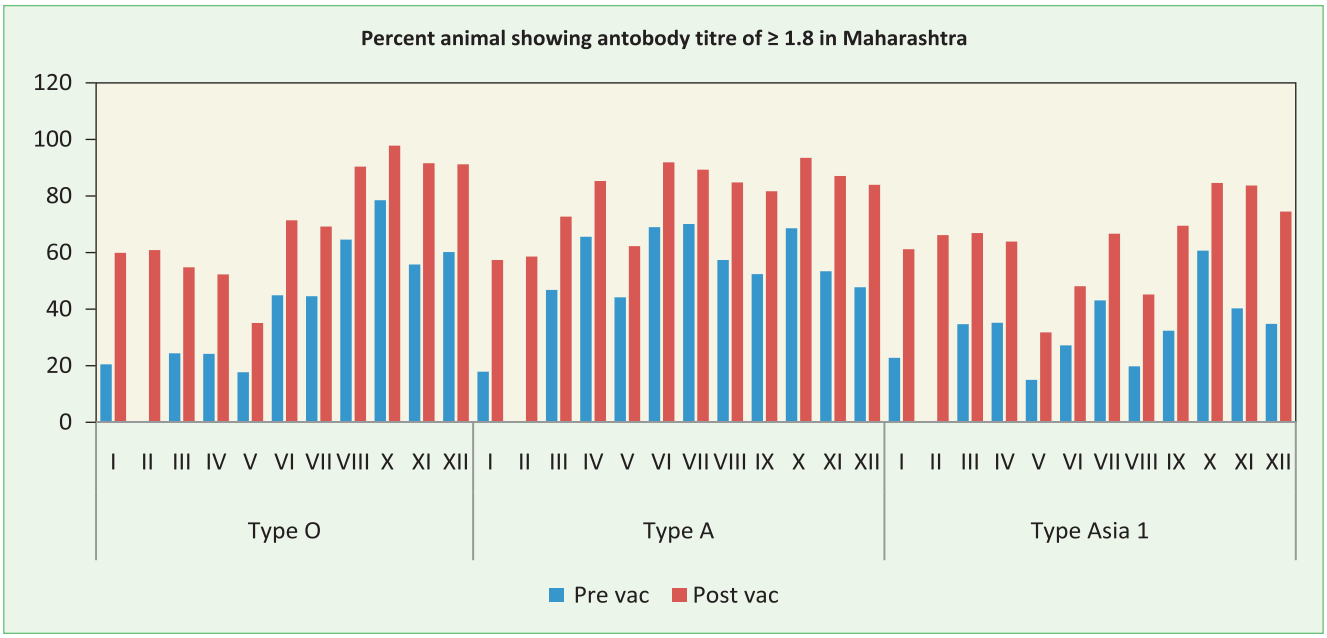


Fig 10.8 Seroconversion in Maharashtra

- In phase XII, 980 pre and 980 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 60.2 for serotype O, 47.75 for serotype A and 34.79 for serotype Asia 1. The same for post-vac samples was 91.2 for type O, 83.97 for type A and 74.48 for serotype Asia 1.
- Overall post-vac response is very good at >70% against all the three serotypes.

Districts included in 2010-11

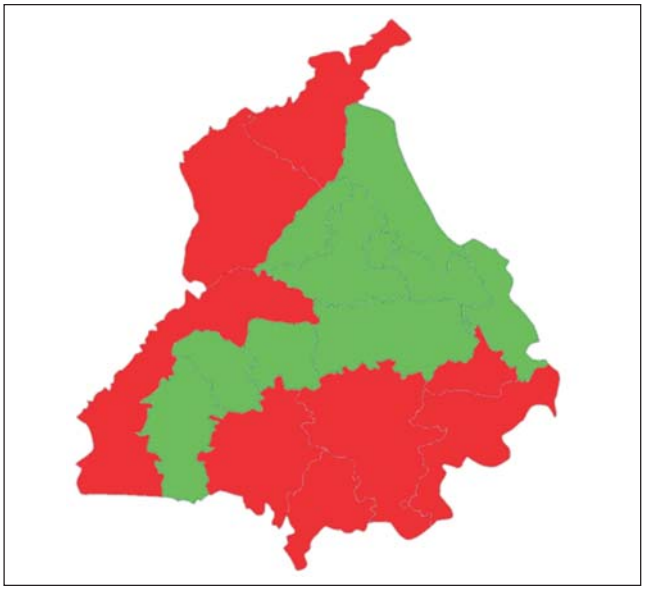
- In phase I, 2153 pre and 2148 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 37.9 for serotype O, 28.47 for serotype A and 19.18 for serotype Asia 1. The same for post-vac samples was 77.89 for type O, 67.46 for type A and 55.31 for serotype Asia 1.
- Protective antibody response is good at >55% after first round of vaccination.

Table 10.9 Result of seroconversion in Maharashtra (2010-11)

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	816(37.9)	1673(77.89)	613(28.47)	1449(67.46)	204(19.18)	1188(55.31)

10.1.9 Sero-monitoring in Punjab

Eight districts of Punjab namely, Amritsar, Bhatinda, Fatehgarh Sahib, Ferozpur , Mansa , Sangrur, Patiala and Gurdaspur were covered under FMDCP in 2003-04 (filled red) and later in 2010-11, rest of the districts (filled green) were included



Districts included in 2003-04

- In phase I, 742 post-vac serum samples were tested. Pre-vac serum samples were not available. Percent serum sample having protective antibody titer of 1.8 and above was 25.2 for type 'O', 11.5 for type 'A' and 49.5 for type 'Asia 1'.
- In phase II, 500 post-vac serum samples were tested. Pre-vac serum samples were not available. Percent serum sample having protective antibody titer of 1.8 and above was 43.8 for type 'O', 20.9 for type 'A' and 58.1 for type 'Asia 1'.
- In Phase III, 1084 pre and 1365 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 84.4 for type 'O', 75.3 for type 'A' and 40.2 for type 'Asia 1'. The same for post-vac samples was 86.1 for type 'O', 73.8 for type 'A' and 42.0 for type 'Asia 1'.
- In phase IV, 1291 pre and 978 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 76.5 for type 'O', 61.5 for type 'A' and 53.8 for type 'Asia 1'. The same for post-vac samples was 81.0 for type 'O', 64.1 for type 'A' and 36.4 for type 'Asia 1'.
- In phase V, 1370 pre and 1139 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 34.8 for type 'O', 32.8 for type 'A' and 38.5 for type 'Asia 1'. The same for post-vac samples was 54.5 for type 'O', 53.7 for type 'A' and 60.1 for type 'Asia 1'.
- In phase VI, 1509 pre and 1568 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 43.3 for type 'O', 43.3 for type 'A' and 32.9 for type 'Asia 1'. The same for post-vac

Table 10.10 Result of seroconversion in Punjab

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	N.A.	187(25.2)	N.A.	90(11.5)	N.A.	273(49.5)
II	Cattle+Buffalo	N.A.	219(43.8)	N.A.	113(20.9)	N.A.	279(58.1)
III	Cattle+Buffalo	915(84.4)	1175(86.1)	816(75.3)	1007(73.8)	437(40.2)	573(42.0)
IV	Cattle+Buffalo	988(76.5)	792 (81.0)	794(61.5)	627 (64.1)	694 (53.8)	356(36.4)
V	Cattle+Buffalo	477(34.8)	621(54.5)	445(32.8)	630(53.7)	513(38.5)	690(60.1)
VI	Cattle+Buffalo	653 (43.3)	944 (60.2)	654 (43.3)	921 (58.7)	496 (32.9)	743 (47.4)
VII	Cattle+Buffalo	520 (41.1)	898 (62.7)	356 (28.1)	639 (44.6)	448 (35.4)	696 (48.6)
VIII	Cattle+Buffalo	580(58.94)	825(73.33)	410(41.66)	643(57.15)	452(45.93)	741(65.86)
IX	Cattle+Buffalo	1035(66.43)	1193(77.16)	831(53.33)	978(63.26)	926(59.43)	1132(73.22)
X	Cattle+Buffalo	1030(64.73)	1231(77.32)	904(56.8)	1098(68.96)	970(60.96)	1156(72.6)
XI	Cattle+Buffalo	1005(61.69)		890(54.63)		986(60.25)	

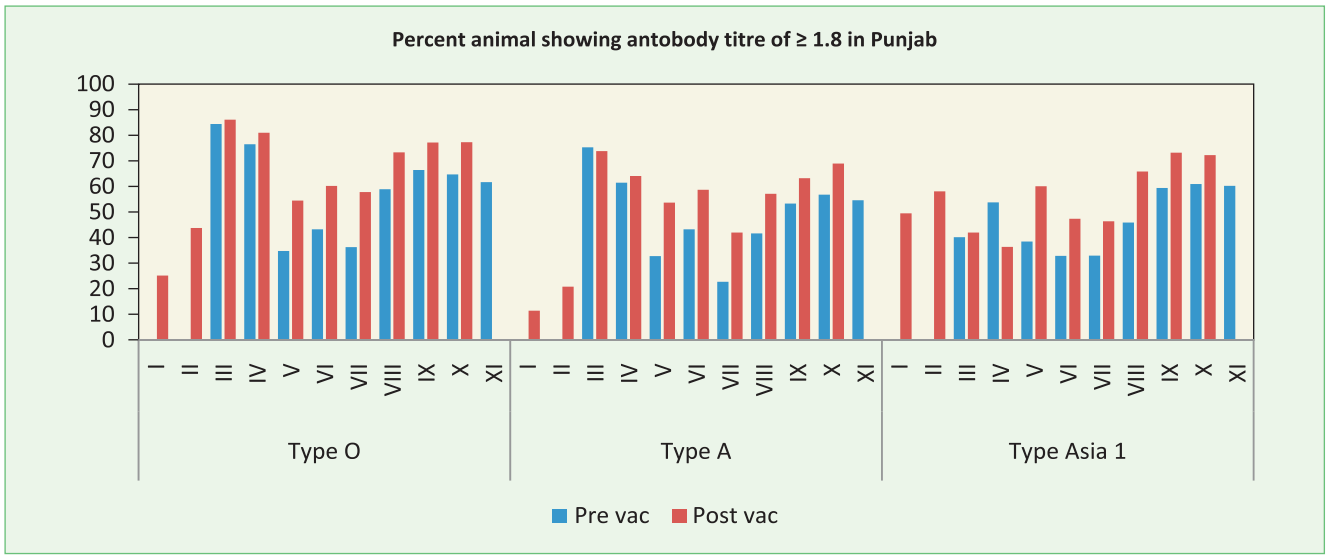


Fig 10.9 Seroconversion in Punjab

samples was 60.2 for type 'O', 58.7 for type 'A' and 47.4 for type 'Asia 1'.

- In phase VII, 1265 pre and 1432 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 36.3 for type 'O', 22.8 for type 'A' and 33.0 for type 'Asia 1'. The same for post-vac samples was 57.8 for type 'O', 42.0 for type 'A' and 46.4 for type 'Asia 1'.
- In phase VIII, 984 pre and 1125 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 58.94 for type 'O', 41.66 for type 'A' and 45.93 for type 'Asia 1'. The same for post-vac samples was 73.33 for type 'O', 57.15 for type 'A' and 65.86 for type 'Asia 1'.
- In phase IX, 1558 pre and 1546 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 66.43 for type 'O', 53.33 for type 'A' and 59.43 for type 'Asia 1'. The same for post-vac samples was 77.16 for type 'O', 63.26 for type 'A' and 73.22 for type 'Asia 1'.
- In phase X, 1592 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-

vac samples was 64.73 for serotype O, 56.81 for serotype A and 60.96 for serotype Asia 1. The same for post-vac samples was 77.32 for type O, 68.96 for type A and 72.61 for serotype Asia 1.

- In phase XI, 1629 pre-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 61.69 for serotype O, 54.63 for serotype A and 60.25 for serotype Asia 1. Testing of post-vac serum samples is under process.
- Overall seroconversion is good at >50% against all the serotypes.

Districts included in 2010-11

- In phase I, 1972 each of pre-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 46.24 for serotype O, 42.08 for serotype A and 34.63 for serotype Asia 1.

Table 10.11 Result of seroconversion in Punjab

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	912(46.24)	Testing in progress	830(42.08)	Testing in progress	683(34.63)	

10.1.10 Sero-monitoring in Tamil Nadu

Only one district, Kanyakumari, was covered under FMDCP in 2003-04 (filled red) and later in 2010-11, rest of the districts (filled green) were included :

District included in 2003-04

- In phase I, each of 100 pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 28 for type 'O', 29 for type 'A' and 24 for type 'Asia 1'. The same for post-vac samples was 51 for type 'O', 57 for type 'A' and 54 for type 'Asia 1'.
- In phase II, each of 100 pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 23 for type 'O', 24 for type 'A' and 18 for type 'Asia 1'. The same for post-vac samples was 63 for type 'O', 40 for type 'A' and 61 for type 'Asia 1'.
- In phase III & IV, 180 pre and 330 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 32.7 for type 'O', 33.8 for type 'A' and 25 for type 'Asia 1'. The same for post-vac samples was 74.5 for type 'O', 60.9 for type 'A' and 65.4 for type 'Asia 1'.
- For phase V, serum samples were not available.
- In phase VI, 160 pre and 130 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 18.7 for type 'O', 23.8 for type 'A' and 21.5 for type 'Asia 1'. The same for post-vac samples was 76.1 for type 'O', 83.8 for type 'A' and 79.2 for type 'Asia 1'.
- In phase VII, 300 pre and 300 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 11.7 for type 'O', 11.3 for type 'A' and 12.0 for type 'Asia 1'. The same for post-vac samples was 70.0 for type 'O', 77.0 for type 'A' and 75.3 for type 'Asia 1'.
- In phase VIII, 100 pre and 100 post-vac serum samples were tested. Percent serum sample having

Table 10.12 Result of seroconversion in Tamil Nadu

Phase	Species	Number & % animals showing titres ≥1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	28(28)	51(51)	29(29)	57(57)	24(24)	54(54)
II	Cattle+Buffalo	23(23.0)	63(63.0)	24(24.0)	40(40.0)	18(18.0)	61(61.0)
III & IV	Cattle+Buffalo	59(32.7)	246(74.5)	61(33.8)	201(60.9)	45(25.0)	216(65.4)
VI	Cattle+Buffalo	30(18.7)	99(76.1)	31(23.8)	109(83.8)	28(21.5)	103(79.2)
VII	Cattle+Buffalo	35(11.7)	210(70)	34(11.3)	231(77)	36(12)	226(75.3)
VIII	Cattle+Buffalo	34(34)	74(74)	40(40)	60(60)	25(25)	78(78)
IX	Cattle+Buffalo	40(40)	58(58)	45(45)	64(64)	33(33)	74(74)
X	Cattle+Buffalo	32(32)	62(62)	45(45)	63(63)	41(41)	70(70)
XI	Cattle+Buffalo	38(19)	144(72)	31(15.5)	87(43.5)	29(14.5)	83(41.5)

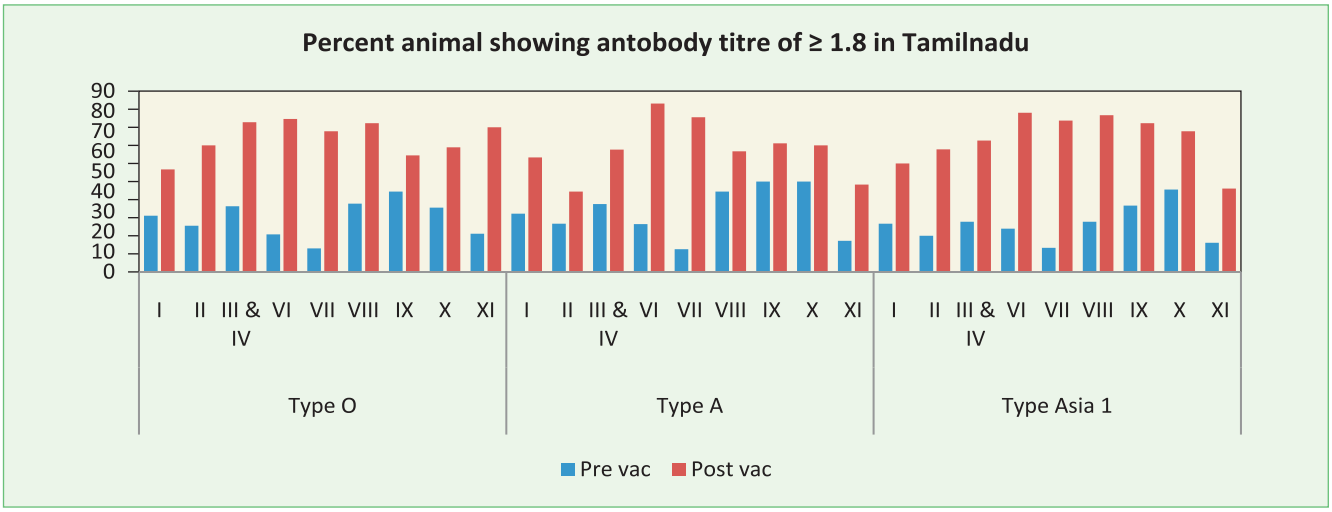


Fig 10.12 Seroconversion in Tamilnadu

protective antibody titer of 1.8 and above for pre-vac samples were 34 for type 'O', 40 for type 'A' and 25 for type 'Asia 1'. The same for post-vac samples was 74 for type 'O', 60 for type 'A' and 78 for type 'Asia 1'.

- In phase IX, 100 pre and 100 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 40 for type 'O', 45 for type 'A' and 33 for type 'Asia 1'. The same for post-vac samples was 58 for type 'O', 64 for type 'A' and 74 for type 'Asia 1'.
- In phase X, 100 pre and 100 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 32 for type 'O', 45 for type 'A' and 41 for type 'Asia 1'. The same for post-vac samples was 62 for type 'O', 63 for type 'A' and 70 for type 'Asia 1'.
- In phase XI, 200 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 19 for serotype O, 15.5 for serotype A and 14.5 for serotype Asia 1. The same for post-vac samples was 72 for type O, 43.5 for type A and 41.5 for serotype Asia 1.
- Sero-conversion against A and Asia 1 is below 50%

Districts included in 2010-11

- In phase I, 2300 each of pre and post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-

Table 10.13 Result of seroconversion in Tamil Nadu (2010-11)

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	825(35.86)	1441(62.6)	593(25.78)	1103(47.95)	492(21.39)	971(42.2)

vac samples was 35.86 for serotype O, 25.78 for serotype A and 21.39 for serotype Asia 1. The same for post-vac samples was 62.6 for type O, 47.95 for type A and 42.2 for serotype Asia 1.

- There is a good boosting effect after first vaccination

10.1.11 Sero-monitoring in Puducherry and Lakshadweep

- In phase I, 30 pre and 55 post-vac serum samples of Pudhucherry were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 44.4 for serotype O, 25 for serotype A and 13.88 for serotype Asia 1. The same for post-vac samples was 66.66 for type O, 55.55 for type A and 30.55 for serotype Asia 1.
- In phase I, 74 pre and 155 post-vac serum samples of Lakshadweep were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 48 for serotype O, 24.3 for serotype A and 36.36 for serotype Asia 1. The same for post-vac samples was 84.4 for type O, 66.2 for type A and 50.65 for serotype Asia 1.

were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was nil for type 'O', 'A' and 'Asia 1'. The same for post-vac samples was 44.2 for type 'O', 38.1 for type 'A' and 72.0 for type 'Asia 1'.

Table 10.14. Result of seroconversion in Puducherry and Lakshadweep

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Puducherry	Cattle+Buffalo	16(44.4)	24(66.66)	9(25)	20(55.55)	5(13.88)	11(30.55)
Lakshadweep	Cattle+Buffalo	37(48)	65(84.4)	9(24.3)	51(66.2)	28(36.36)	39(50.65)

10.1.12 Sero-monitoring in 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 2003-04 (Red). No new districts included during the expansion in 2010-11.

- No serum samples were received for phase I.
- In phase II, 139 and 407 post-vac serum samples
- In phase III, 1155 and 1584 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 34.5 for type 'O', 42.7 for type 'A' and 42.4 for type 'Asia 1'. The same for post-vac samples was 49.2 for type 'O', 57.4 for type 'A' and 71.8 for type 'Asia 1'.
- In phase IV, 1910 and 1770 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-

Table 10.15 Result of seroconversion in Uttar Pradesh

Phase	Species	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
		Type O		Type A		Type Asia 1	
		Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
I	Cattle+Buffalo	Serum samples not available					
II	Cattle+Buffalo	0(0)	180(44.2)	0(0)	155(38.1)	0(0)	293(72.0)
III	Cattle+Buffalo	399(34.5)	780(49.2)	494(42.7)	910(57.4)	490(42.4)	1138(71.8)
IV	Cattle+Buffalo	344(18.0)	537(30.3)	610(31.9)	866(48.9)	519(27.2)	808(45.6)
V	Cattle+Buffalo	516(35.8)	715(44.9)	625(43.4)	802(50.4)	684(47.5)	786(49.4)
VI	Cattle+Buffalo	514(34.5)	968 (61.3)	520 (34.9)	826 (52.3)	400 (26.9)	838 (53.1)
VII	Cattle+Buffalo	706 (24.9)	911 (43.9)	597 (21.1)	808 (38.9)	740 (26.1)	930 (44.8)
VIII	Cattle+Buffalo	707(37.1)	1550(56.5)	502(26.4)	1310(47.7)	617(32.41)	1288(46.9)
IX	Cattle+Buffalo	927(33.56)	1198(39.9)	617(22.34)	1095(36.48)	597(21.6)	1072(35.7)

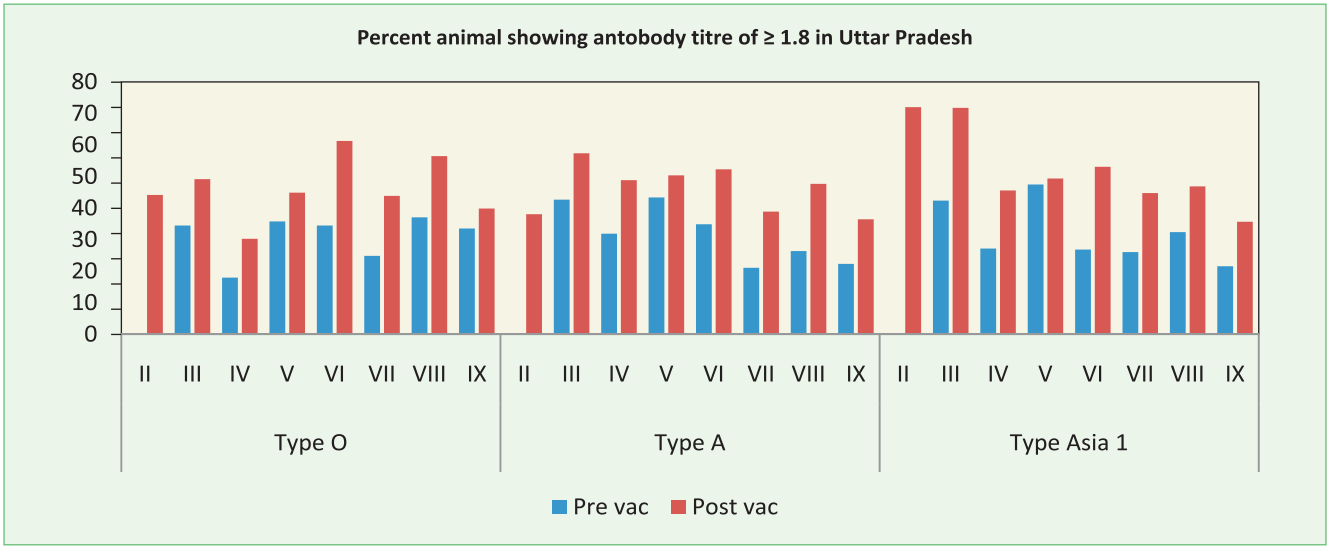


Fig 10.11 Seroconversion in Uttar Pradesh

vac samples were 18 for type 'O', 31.9 for type 'A' and 27.2 for type 'Asia 1'. The same for post-vac samples was 30.3 for type 'O', 48.9 for type 'A' and 45.6 for type 'Asia 1'.

- In phase V, 1440 pre and 1591 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 35.8 for type 'O', 43.4 for type 'A' and 47.5 for type 'Asia 1'. The same for post-vac samples was 44.9 for type 'O', 50.4 for type 'A' and 49.4 for type 'Asia 1'.
- In phase VI, 1488 pre and 1579 post vac serum samples out of total 2182 pre and 1986 post vac serum samples collected were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples were 34.5 for type 'O', 34.9 for type 'A' and 26.9 for type 'Asia 1'. The same for post-vac samples was 61.3 for type 'O', 52.3 for type 'A' and 53.1 for type 'Asia 1'.
- In phase VII, 2833 pre and 2075 post vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for a pre-vac sample was 23.4 for type 'O', 18.6 for type 'A' and 19.3 for type 'Asia 1'. The same for post-vac samples was 43.9 for type 'O', 38.9 for type 'A' and 44.8 for type 'Asia1'.
- In phase VIII at present 1904 pre and 2744 post vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for a pre-vac sample was 37.1 for type 'O', 26.4 for type 'A' and 32.41 for type 'Asia 1'. The same for post-vac samples was 56.5 for type 'O',

47.7 for type 'A' and 46.9 for type 'Asia 1'.

- In phase IX, 2762 pre and 3002 post-vac serum samples were tested. Percent serum sample having protective antibody titer of 1.8 and above for pre-vac samples was 33.56 for serotype O, 22.34 for serotype A and 21.6 for serotype Asia 1. The same for post-vac samples was 39.9 for type O, 36.48 for type A and 35.7 for serotype Asia 1.

10.2 Phase wise number and percent of animals showing antibody titer ≥ 1.8 log_{10} against FMD virus from phase I to XII (54 districts)

Table 10.16 Phase I

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman& Nicobar	Serum samples not available					
Andhra Pradesh	83 (10.3)	340 (42.5)	43 (5.3)	244 (30.5)	92 (11.5)	340 (42.5)
Delhi	26 (53)	50 (100)	13 (26)	47 (94)	17 (34)	48 (96)
Gujarat	50 (19.1)	116 (44.7)	59 (24.5)	128 (48.7)	42 (16.1)	114 (43.5)
Haryana	Serum samples not available					
Kerala*	158(32.7)	255(51.4)	140(29.0)	236(47.5)	165(34.2)	280(56.4)
Maharashtra	173 (20.5)	456 (59.9)	151(17.9)	437 (57.4)	192 (22.8)	466 (61.2)
Punjab	N.A.	187(25.2)	N.A.	90(11.5)	N.A.	273(49.5)
Tamil Nadu	28(28)	51(51)	29(29)	57(57)	24(24)	54(54)
Uttar Pradesh	Serum samples not available					

* Kerala Phase I, II & IV data is combined.

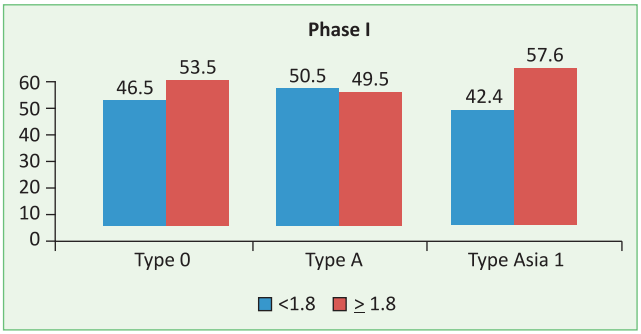


Fig 10.12 Average post vaccinal seroconversion in Phase I

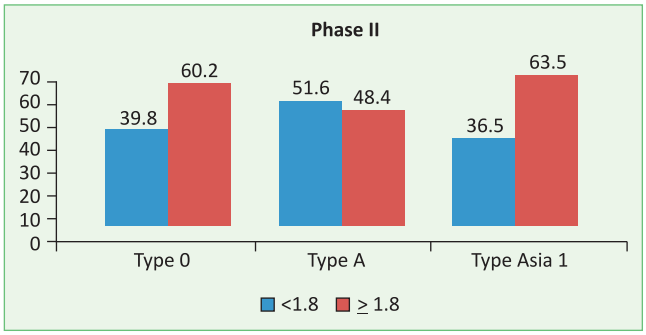


Fig 10.13 Average post vaccinal seroconversion in Phase II

Table 10.17 Phase II

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman& Nicobar	Serum samples not available					
Andhra Pradesh	N.A.	434 (54.2)	N.A.	498 (62.3)	N.A.	438 (54.7)
Delhi	22 (91)	23 (96)	12 (40)	15 (62)	23 (95)	22 (86)
Gujarat	Serum samples not available					
Haryana	NA	1065(68.3)	NA	859 (55.1)	NA	831 (53.3)
Kerala*	158(32.7)	255(51.4)	140(29.0)	236(47.5)	165(34.2)	280(56.4)
Maharashtra	N.A.	508 (60.9)	N.A.	490 (58.6)	N.A.	553 (66.2)
Punjab	N.A.	219(43.8)	N.A.	113(20.9)	N.A.	279(58.1)
Tamil Nadu	23(23.0)	63(63.0)	24(24.0)	40(40.0)	18(18.0)	61(61.0)
Uttar Pradesh	0(0)	180(44.2)	0(0)	155(38.1)	0(0)	293(72.0)

* Kerala Phase I, II & IV data is combined.

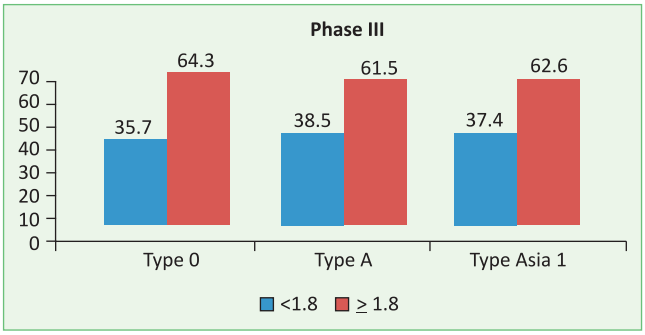


Fig 10.14 Average post vaccinal seroconversion in Phase III

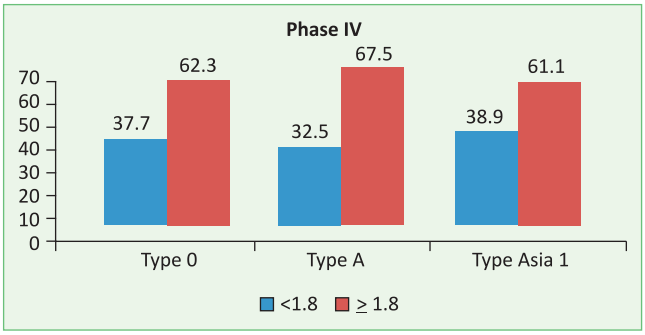


Fig 10.15 Average post vaccinal seroconversion in Phase IV

Table 10.18 Phase III

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman & Nicobar	40(25.9)	97(60.0)	5(2.8)	37(20.3)	52(34.0)	118(73.6)
Andhra Pradesh	210 (26.2)	286 (35.7)	395 (49.3)	532 (66.5)	306 (38.2)	422 (52.7)
Delhi	47 (94)	49 (98)	30 (60)	40 (80)	43 (86)	46 (92)
Gujarat	123 (27.8)	171 (47.9)	171 (39.2)	268 (58.3)	51 (12.4)	149 (35.4)
Haryana	NA	1146(72.3)	NA	1007(63.6)	NA	1005(63.4)
Kerala	Serum samples not available					
Maharashtra	184 (24.4)	438 (54.8)	351 (46.8)	580 (72.7)	262 (34.7)	534 (66.9)
Punjab	915(84.4)	1175(86.1)	816(75.3)	1007(73.8)	437(40.2)	573(42.0)
Tamil Nadu**	59(32.7)	246(74.5)	61(33.8)	201(60.9)	45(25.0)	216(65.4)
Uttar Pradesh	399(34.5)	780(49.2)	494(42.7)	910(57.4)	490(42.4)	1138(71.8)

** Tamil Nadu Phase III & IV data is combined

Table 10.19 Phase IV

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman&Nicobar	50(33.5)	94(64.6)	50(33.5)	96(65.9)	35(23.4)	101(67.6)
Andhra Pradesh	281 (35.1)	374 (46.8)	465 (58.1)	617 (77.1)	329 (41.1)	518 (64.8)
Delhi	38 (76)	38 (82.6)	14 (28)	40 (86.9)	27 (54)	41 (89.1)
Gujarat	113 (22.7)	277 (60.7)	184 (40.7)	355 (81.2)	73 (14.6)	218 (46.8)
Haryana	953 (60.1)	1222(78.7)	668 (42.1)	887 (57.1)	844 (53.2)	1170(75.3)
Kerala*	158(32.7)	255(51.4)	140(29.0)	236(47.5)	165(34.2)	280(56.4)
Maharashtra	191 (24.2)	417 (52.3)	517 (65.6)	679 (85.3)	278 (35.2)	509 (63.9)
Punjab	988(76.5)	792 (81.0)	794(61.5)	627 (64.1)	694 (53.8)	356(36.4)
Tamil Nadu**	59(32.7)	246(74.5)	61(33.8)	201(60.9)	45(25.0)	216(65.4)
Uttar Pradesh	344(18.0)	537(30.3)	610(31.9)	866(48.9)	519(27.2)	808(45.6)

* Kerala Phase I, II & IV data is combined;
* *Tamil Nadu Phase III & IV data is combined.

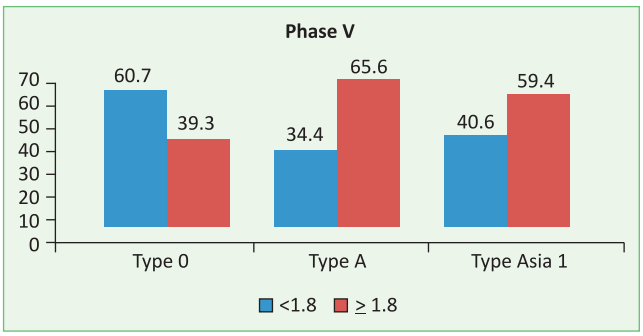


Fig 10.16 Average post vaccinal seroconversion in Phase V

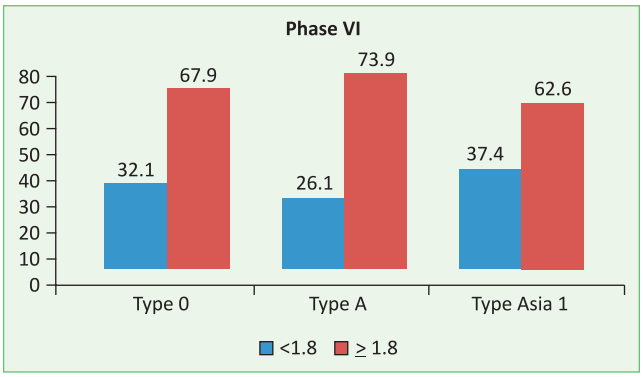


Fig 10.17 Average post vaccinal seroconversion in Phase VI

Table 10.20 Phase V

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman & Nicobar	72(57.2)	68(55.8)	62(50.8)	64(52.5)	54(44.3)	62(50.8)
Andhra Pradesh	247 (30.8)	440 (55)	466 (58.2)	574 (71.8)	343 (42.8)	450 (56.3)
Delhi	26 (59)	47 (88.6)	23 (52.2)	37 (69.8)	32 (72.7)	41 (77.3)
Gujarat	46 (23.6)	99 (49.0)	126 (66.1)	179 (91.6)	44 (26.5)	92 (51.3)
Haryana	955 (59.7)	1352(84.5)	813 (50.8)	1274(79.6)	941 (58.8)	1353(84.5)
Kerala	67(23.1)	197(67.9)	52(17.9)	171(58.9)	61(21.0)	211(72.7)
Maharashtra	142 (17.7)	271 (35.1)	353 (44.2)	477 (62.3)	121 (15.0)	245 (31.8)
Punjab	477(34.8)	621(54.5)	445(32.8)	630(53.7)	513(38.5)	690(60.1)
Tamil Nadu	Serum samples not available					
Uttar Pradesh	516(35.8)	715(44.9)	625(43.4)	802(50.4)	684(47.5)	786(49.4)

Table 10.21 Phase VI

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman & Nicobar	50 (18.5)	80 (29.6)	66 (24.4)	104 (38.4)	28 (10.2)	36 (13.2)
Andhra Pradesh	275 (34.3)	490 (61.3)	554 (69.2)	690 (86.3)	446 (55.7)	634 (79.3)
Delhi	76 (77.5)	97 (98.9)	60 (61.2)	93 (94.9)	71 (72.4)	97 (98.9)
Gujarat	119 (30.1)	223 (56.4)	249 (63.0)	317(80.2)	195 (49.3)	240 (60.7)
Haryana	995 (66.5)	1306(87.1)	895 (59.8)	1229(82.0)	844 (56.4)	1118(74.6)
Kerala	49 (20.4)	185(77.1)	41(17.1)	169(70.4)	38(15.8)	171(71.3)
Maharashtra	404 (44.9)	663 (71.4)	622 (69)	853 (91.9)	245 (27.2)	446 (48.1)
Punjab	653 (43.3)	944 (60.2)	654 (43.3)	921 (58.7)	496 (32.9)	743 (47.4)
Tamil Nadu	30(18.7)	99(76.1)	31(23.8)	109(83.8)	28(21.5)	103(79.2)
Uttar Pradesh	514 (34.5)	968 (61.3)	520 (34.9)	826 (52.3)	400 (26.9)	838 (53.1)

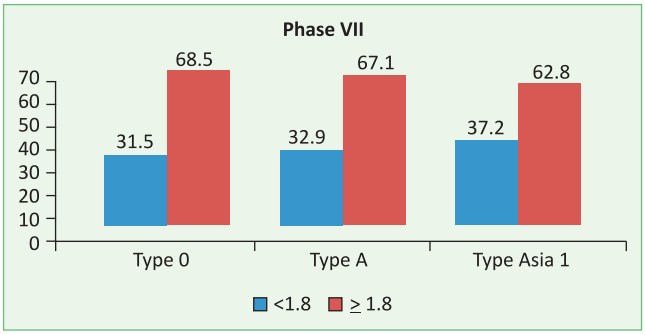


Fig 10.18 Average post vaccinal seroconversion in Phase VII

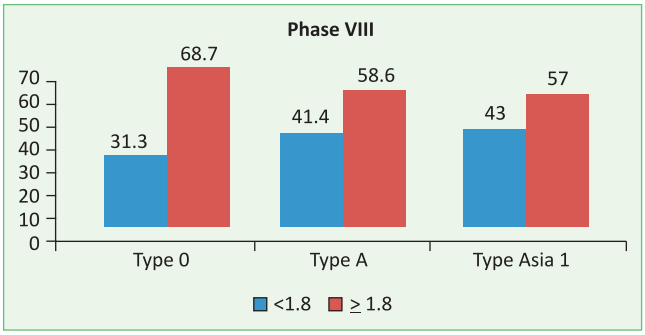


Fig 10.19 Average post vaccinal seroconversion in Phase VIII

Table 10.22 Phase VII

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman & Nicobar	112 (42.3)	174 (65.7)	82 (30.9)	110 (41.5)	56 (21.1)	66 (24.9)
Andhra Pradesh	274 (34.0)	483 (60.3)	349 (44.0)	540 (67.5)	391 (48.8)	518 (64.7)
Delhi	39(78)	44(88)	33(66)	43(86)	25(50)	41(82)
Gujarat	434 (54.3)	630 (78.8)	385 (48.1)	559 (69.9)	344 (43.0)	556 (69.5)
Haryana	856(54.8)	1296 (82.3)	1021 (65.3)	1380 (87.6)	888 (56.8)	1317 (83.6)
Kerala	48 (16.0)	208 (69.3)	43 (14.3)	213 (71.0)	52 (17.3)	210 (70.0)
Maharashtra	446 (44.6)	692 (69.2)	701 (70.1)	893 (89.3)	431 (43.1)	667 (66.7)
Punjab	413 (36.3)	650 (57.8)	260 (22.8)	472 (42.0)	376 (33.0)	521 (46.4)
Tamil Nadu	35(11.7)	210(70)	34(11.3)	231(77)	36(12)	226(75.3)
Uttar Pradesh	706 (24.9)	911 (43.9)	597 (21.1)	808 (38.9)	740 (26.1)	930 (44.8)

Table 10.23 Phase VIII

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman& Nicobar	53(21.1)	102(40.6)	18(7.2)	49(19.5)	47(18.7)	85(33.86)
Andhra Pradesh	356 (44.5)	594 (74.0)	415 (51.8)	624 (78.0)	333 (41.6)	527 (65.8)
Delhi	92 (92)	100 (100)	66 (66)	86 (86)	83 (83)	98 (98)
Gujarat	191 (23.9)	394 (49.3)	197 (24.6)	357 (44.6)	264 (33.0)	403 (50.4)
Haryana	949(61.3)	1289 (83.7)	877 (56.6)	992 (64.4)	765 (49.4)	1101 (71.4)
Kerala*	226(37.6)	395(65.8)	265(44.16)	341(56.8)	260(43.3)	397(66.2)
Maharashtra	646 (64.6)	904 (90.4)	574 (57.4)	848 (84.8)	198 (19.8)	452 (45.2)
Punjab	580(58.94)	825(73.3)	410(41.66)	643(57.15)	452(45.93)	741(65.86)
Tamil Nadu	34(34)	74(74)	40(40)	60(60)	25(25)	78(78)
Uttar Pradesh	707(37.1)	1550(56.5)	502(26.4)	1310(47.7)	617(32.4)	1288(46.9)

* Kerala Phase VIII & IX data is combined

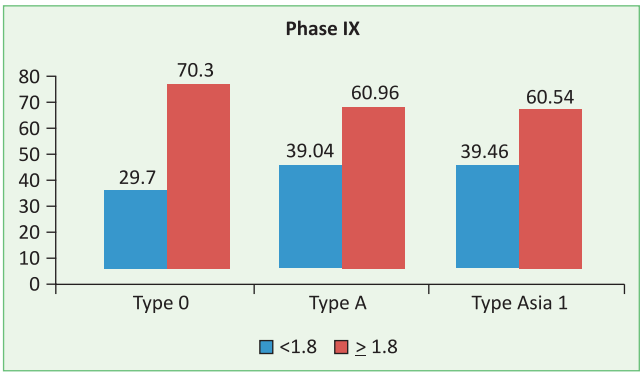


Fig 10.20 Average post vaccinal seroconversion in Phase IX

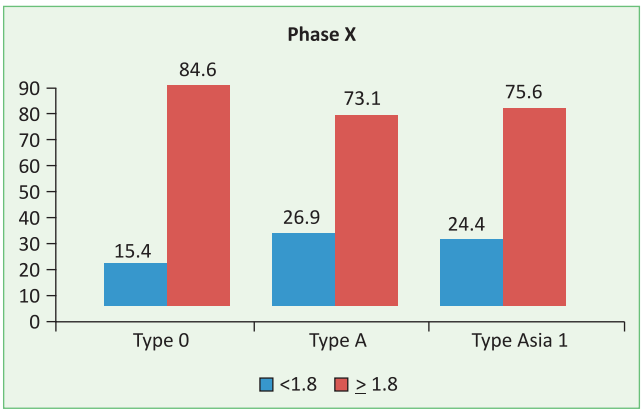


Fig 10.21 Average post vaccinal seroconversion in Phase X

Table 10.24 Phase IX

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman & Nicobar	73(32)	69(30.26)	31(13.59)	35(15.35)	56(24.56)	42(18.42)
Andhra Pradesh	422(52.8)	673(84.1)	329(41.1)	534(66.8)	287(35.9)	534(66.8)
Delhi	57(57)	NA	65(65)	NA	33(33)	NA
Gujarat	230(28.7)	618(77.2)	284(35.5)	572(71.5)	326(40.7)	595(66.9)
Haryana	647(43.2)	1140(77.2)	590(39.4)	1022(69.2)	410(27.4)	879(59.6)
Kerala*	226(37.6)	395(65.8)	265(44.16)	341(56.8)	260(43.3)	397(66.2)
Maharashtra	730(73)	951(95.1)	524(52.4)	817(81.7)	324(32.4)	695(69.5)
Punjab	1035(66.4)	1193(77.2)	831(53.3)	978(63.3)	926(59.4)	1132(73.2)
Tamil Nadu	40(40)	58(58)	45(45)	64(64)	33(33)	74(74)
Uttar Pradesh	927(33.56)	1198(39.9)	617(22.34)	1095(36.48)	597(21.6)	1072(35.7)

* Kerala Phase VIII & IX data is combined

Table 10.25 Phase X

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman& Nicobar	Serum testing in Progress					
Andhra Pradesh	502(62.7)	635(79.3)	368(46)	575(71.8)	411(51.3)	602(75.2)
Delhi	Samples not available					
Gujarat	356(44.5)	620(77.5)	286(35.7)	525(65.6)	276(34.5)	535(66.9)
Haryana	851(59.9)	1350(93.8)	615(43.3)	1003(69.7)	587(41.3)	1145(79.5)
Kerala	160(40)	59(59)	145(36.25)	66(66)	150(37.5)	53(53)
Maharashtra	785(78.5)	978(97.8)	686(68.6)	935(93.5)	607(60.7)	846(84.6)
Punjab	1030(64.73)	1231(77.32)	904(56.8)	1098(68.96)	970(60.96)	1156(72.6)
Tamil Nadu	32(32)	62(62)	45(45)	63(63)	41(41)	70(70)
Uttar Pradesh	Serum testing in Progress					

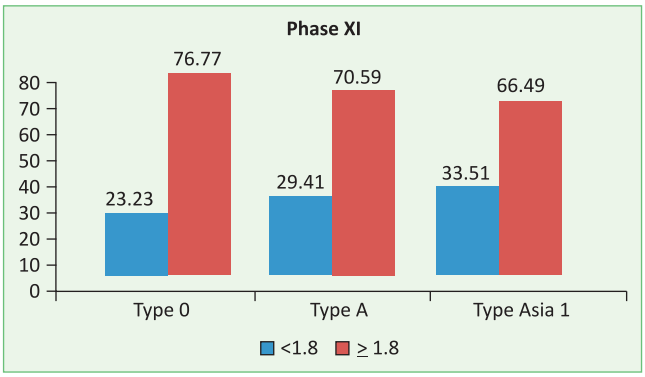


Fig 10.22 Average post vaccinal seroconversion in Phase XI

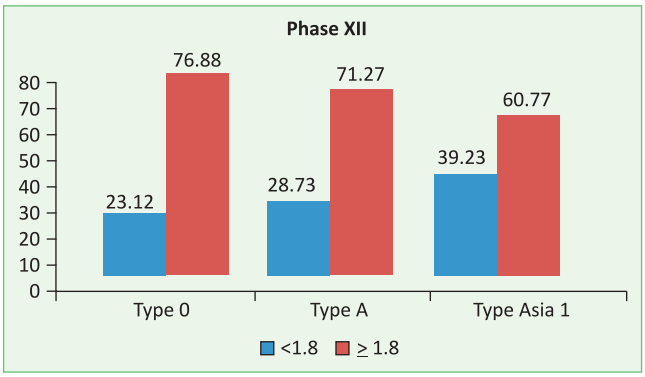


Fig 10.23 Average post vaccinal seroconversion in Phase XII

Table 10.26 Phase XI

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman & Nicobar						
Andhra Pradesh	398(49.75)	617(77.12)	356(44.5)	600(75)	333(41.62)	568(71.5)
Delhi	172(86)	NA	100(50)	NA	91(45.5)	NA
Gujarat	55(27.5)	76(38)	44(22)	71(35.5)	29(14.5)	49(24.5)
Haryana	734(48.9)	1302(88.9)	546(36.4)	1180(80.6)	455(30.3)	1109(75.8)
Kerala						
Maharashtra	558(55.8)	916(91.6)	534(53.4)	871(87.1)	403(40.3)	837(83.7)
Punjab	1005(61.69)	NA	890(54.63)	NA	986(60.25)	NA
Tamil Nadu	38(19)	144(72)	31(15.5)	87(43.5)	29(14.5)	83(41.5)
Uttar Pradesh						

Table 10.27 Phase XII

State	Number & % animals showing titres ≥ 1.8 log_{10} against FMDV					
	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Andaman & Nicobar	36(20.0)	49(27.22)	19(10.56)	40(22.22)	11(6.11)	30(16.67)
Andhra Pradesh	387(48.37)	568(71)	266(33.25)	483(60.37)	177(22.12)	367(45.87)
Delhi						
Gujarat	104(52)	105(52.5)	80(40)	67(33.5)	56(28)	25(12.5)
Haryana	593(43.6)	975(80.6)	520(38.2)	989(81.7)	474(34.9)	896(74.1)
Kerala						
Maharashtra	590(60.2)	894(91.2)	468(47.75)	823(83.97)	341(34.79)	730(74.48)
Punjab						
Tamil Nadu						
Uttar Pradesh						

10.2.1 Summary of overall sero conversion in phases I to XII against each serotype and impact of vaccine

The herd immunity has progressively increased with minor aberrations that speak for positive impact of vaccination for last 6-7 years. Incidence/occurrence of the disease has also progressively declined in these areas down to near zero. In recent times, there has been case of FMD in some 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 6-8 PD50/dose. The results have been encouraging and should be further strengthened by constituting a National FMD Commission.

Table 10.28 Percent animals showing post vaccinal antibody titers of $\geq 1.8 \log_{10}$ against FMD virus

Phase	Type O		Type A		Type Asia 1	
	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post vac
I	27.3	53.5	22.0	49.5	23.8	57.6
II	36.7	60.2	23.3	48.4	36.8	63.5
III	43.7	64.3	43.7	61.5	39.1	62.6
IV	41.2	62.3	42.4	67.5	36.2	61.1
V	38.0	39.3	46.3	65.6	40.8	59.4
VI	38.9	67.9	46.6	73.9	36.8	62.6
VII	39.7	68.5	39.4	67.1	35.1	62.8
VIII	42.3	68.7	37	58.6	33.5	57
IX	63.7	85.6	52	73.3	52.6	73
X	63.4	87.4	50.6	74.7	48.9	76.7
XI	50.76	76.66	42.89	70.59	39.89	66.49
XII	48.57	76.88	38.4	71.27	30.08	60.77

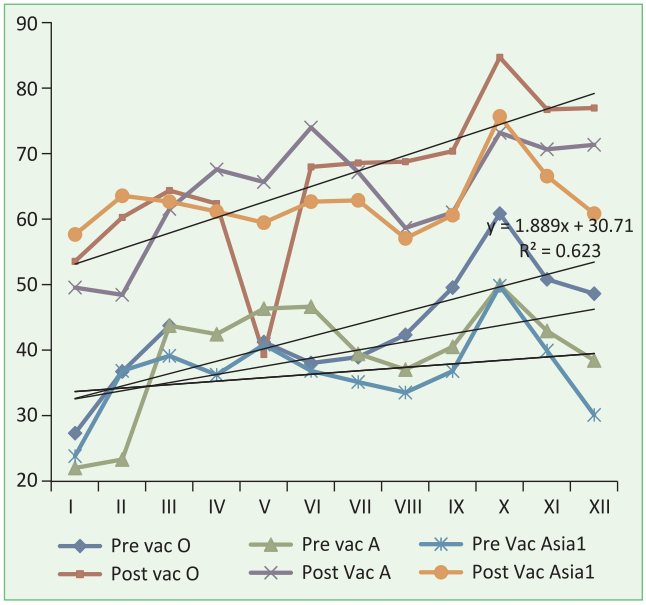


Fig 10.24 Overall seroconversion after phase XII pre and post vac serum samples under FMD-CP

Table 10.29 Summary of total number of serum samples tested under FMD CP (2010-11)

State/UT	Phase I		Phase II	
	Pre	Post	Pre	Post
Andhra Pradesh	3600	3600	1600	1600
Karnataka	645	396	-	-
Maharashtra	2153	2148	-	-
Punjab	1972	-	-	-
Tamilnadu	2300	2300	-	-
Puducherry	36	36	-	-
Lakshadweep	77	77	-	-
Total	10,783	8557	1600	1600
Grant total	22,540			

Table 10.30 Summary of total number of serum samples tested under FMD CP (2003-04)

State/UT	Phase I		Phase II		Phase III		Phase IV		Phase V		Phase VI		Phase VII		Phase VIII		Phase IX		Phase X		Phase XI		Phase XII	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Andaman &Nicobar	-	-	-	-	154	162	149	146	126	122	270	270	265	265	251	251	228	228	-	-	-	-	180	180
Andhra Pradesh	800	800	-	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
Delhi	50	50	24	24	50	50	50	46	44	53	98	98	50	50	100	100	100	-	-	-	200	-	-	-
Gujarat	382	259	-	-	442	357	497	456	195	202	395	395	800	800	800	800	800	800	800	800	200	200	200	200
Haryana	-	-	-	1558	-	1585	1589	1552	1600	1599	1496	1499	1562	1574	1547	1540	1497	1476	1420	1439	1500	1464	1360	1210
Kerala	483 (pre) and 496 (post) of Phase I, II and IV								290	290	70	70	300	300	600 (pre)	600 (post)	400	100	352	315				
Maharashtra	844	761	-	834	753	799	789	797	802	772	901	928	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	980	980
Punjab	-	742	-	500	1084	1365	1291	978	1370	1139	1509	1568	1265	1432	984	1125	1558	1546	1592	1592	1629	-	-	-
Tamilnadu	100	100	100	100	180 (pre)	330 (post)	-	-	160	130	300	300	100	100	100	100	100	100	200	200	-	-		
Uttar Pradesh	-	-	139	407	1155	1584	1910	1770	1440	1591	1488	1579	2833	2075	1904	2744	2762	3002	-	-	-	-	-	-
Subtotal	2176	2712	263	4223	4438	6707	7075	6545	6667	6568	7187	7337	9175	8596	8086	8460	8845	8952	6112	5831	5881	3979	3520	3370
Total	4888*		4486*		11145*		13620*		13235		14524		17771		16546*		17797*		11943		9860		6890	
Grand total	Pre-vac 57481**								post-vac-62433**															

* excluding the samples of Phase I, II, IV, VIII and IX from Kerala; Phase III and IV from Tamilnadu as samples of this phases were mixed up at the level of collection and labelling
**this includes all the samples tested

10.3 Sero-monitoring of post vaccinal immunity against serotypes O, A and Asia1 in animals vaccinated under ASCAD/ RKVY programmes

Table 10.3.1 Results of serum samples tested during 2011-12; sampling was done at random, and not as per FMD-CP format

State	Number of sample tested	Species	Number & % animals showing titres ≥ 1.8 $\log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
			Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
Manipur	145+132	C+B	6(4.13)	39(29.54)	13(8.9)	17(12.87)	8(5.51)	0(0)
Mizoram	300+153	C+B	88(29.3)	77(50.3)	65(21.6)	71(46.4)	26(8.6)	15(9.8)
Nagaland	239+209	C+B	58(24.2)	67(32)	39(16.3)	106(50.7)	18(7.5)	68(32.5)
Kerala	764+761	C	169(11.08)	278(18.22)	108(7.08)	197(12.9)	110(7.21)	205(13.44)
Bihar	110+110	C+B	18(16.36)	30(27.27)	3(2.72)	18(16.36)	4(3.64)	16(14.55)
Nagaland	110+110	C	29(26.36)	95(86.36)	28(25.45)	88(80)	8(7.27)	57(51.82)
Tripura	100+100	C	23(23)	83(83)	20(20)	81(81)	12(12)	69(69)

Percent animals showing post vaccinal antibody titers of e"1.8 $\log_{10}$ against FMD virus is in parenthesis

11.0

Production, Standardization and Supply of Diagnostic Reagents

For production of reagents, the vaccine virus strains {O (IND R2/75), Asia1 (IND 63/72),) and A (IND 40/00)} were bulk produced in roller culture vessels and purified by density gradient centrifugation. Inactivated virus antigen was also outsourced from a FMD vaccine production house (Indian Immunological Ltd) in the country to meet demand for diagnostic kits in the region. Antibodies against purified virus was raised and titrated against homologous as well as heterologous virus. Freeze dried and standardized serum antibodies (rabbit and guinea pig) 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 LPB-ELISA. Recombinant 3AB3 NSP was produced as per requirement.

During the period under report, r3AB3 DIVA Kit for FMD to test a total number of 92, 000 serum samples was produced and reagents to test 61,670 samples have been supplied to the AICRP units and vaccine manufacturing companies. Similarly, virus serotyping Kits for 10,000 tests, LPB-ELISA Kits for 1, 54,600 were supplied to FMD Regional centers/ network units for sero-surveillance and monitoring of FMD. Diagnostic kits were also supplied to SAARC Countries.

Details of the supply is shown in Table:

S. No.	Party to which supplied	Typing ELISA (No. of test)	LPB ELISA (No. of test)	DIVA (No. of test)
1.	AICRP Regional Center and Network Units, India	5500	122600	52970
2.	Vaccine manufacturing industries and testing agency, India	1500	14000	6000
3.	SAARC countries	3000	18000	2700
	Total	10,000	1,54,600	61,670

12.0

Reports and Recommendations

PROCEEDINGS OF THE 22nd ANNUAL REVIEW MEETING OF THE AICRP ON FMD PROJECT DIRECTORATE ON FOOT AND MOUTH DISEASE

The 22nd Annual Review Meeting of the AICRP on FMD of the Project Directorate on Foot and Mouth Disease (PD on FMD) for the year 2010-11 was held on 29 –30 September 2011 in the meeting room of the Government Guest House, Thycaud, Thiruvananthapuram, Kerala. Scientists of all the Regional centers (8) and Network units (14) participated in this meet. The Network Unit, Itanangar, Arunachal Pradesh did not participate. There were special invitees, and other dignitaries participated in the meeting.

The meeting was chaired by Prof. Gaya Prasad, ADG (AH), ICAR. The special invitees were Dr. R. Venkataramanan (Joint Director, IVRI Campus, Bangalore), Dr Vijay Kumar (Director, Dept. of Animal Husbandry and Veterinary Science, Govt. of Kerala) and Dr. K.A. Naveen (Joint Director, NIAH, Baghpat).

Dr. B Pattnaik, Project Director welcomed the Chairman, the dignitaries and participating scientists of Regional centers and Network Units. He emphasized that AICRP on FMD is an in-built component of PDFMD and under AICRP there are 8 Regional Centers and 15 Network Units catering to the need of epidemiology, surveillance, national serominotoring and FMD control programme (FMDCP) in the country. PDFMD is supplying diagnostic reagents with Standard Operating Procedure (SOP) for uniformity in diagnosis and monitoring of FMD in the country and has also supplied trial kits to SAARC member countries. PDFMD is also providing specialized service and training on FMD diagnosis in the country. He informed the house that due to systematic vaccination followed by rigorous monitoring, the incidence of FMD outbreaks has reduced in number with reduced severity of the disease over the years in the 54 districts covered under FMDCP. He further informed that the institute now also functions as SAARC Regional Leading Diagnostic Laboratory for FMD.

Prof. Gaya Prasad, ADG (AH), ICAR informed that AICRP on FMD is the earliest research coordinated research programme in the country which is in testimony that FMD is the biggest threat to animal health and poverty alleviation in the country. FMD virus is continued to be a difficult virus and challenge to policy makers and scientists. Now India cannot trade on livestock and its product to FMD free countries. There are certain other challenges before us to be addressed like short duration of immunity, thermo lability of the vaccine, and to develop systems to detect persistence of virus in vaccinated animals. AICRP on FMD is a mission for the poor livestock owners in the country and PDFMD has gone an extra mile in the scientific management of the most dreaded disease of livestock like FMD. He expressed that this is an programme which has seen success and India is self-reliant in diagnostics and vaccines required for control and eradication of the disease.

Dr. Pattnaik presented the action taken report of the 21st ARM. He informed the house that FMD monitoring activity in A&N Islands has been shifted from the Kolkata Center to the CARI, Portblair, to address certain intrinsic problems. During the discussion, Prof. Gaya Prasad expressed his unhappiness with the performance of the Lucknow center and suggested for serious efforts for the real time monitoring of FMD in a huge state like Uttar Pradesh. He emphasized to provide BSL-2 facilities to the regional

centers of AICRP on FMD during the 12th Plan Period. Dr. A. Sanyal, Principal Scientist, presented the report of the Central FMD Laboratory, Mukteswar and highlighted the achievements.

Presentations were made by the In-charges of 08 Regional Centers and 14 Network Units. There was detailed deliberation on presentations made by all the centers/network units. The regional centers and network units of AICRP on FMD were graded (A, B, C and D), based on their performance. Amongst them the Hisar and Hyderabad centers were adjudged as the first and second best regional centers respectively. Manipur and Thiruvananthapuram were adjudged as the first and second best network units respectively.

The chairman expressed happiness over the performance of the AICRP and PD on FMD in investigating epidemiology of the disease from time to time, and in assessing impact of the vaccination on occurrence of the disease. After detailed discussion under the chairmanship of Prof. Gaya Prasad in the presence of Dr. B Pattnaik, and other special invitees, the following recommendations were made:

Recommendations

Scientific and Technical

1. The incidence of FMD outbreaks are mostly observed in post monsoon period, so biannual vaccination regime of animals should be carried during March and September of each year. The neighboring state(s) should also vaccinate the animals during the same period (**Action: DAHD&F/ State AH Department**).
2. Monovalent vaccination against serotype O virus may be adopted in limited areas as an experimental study as there are indications that quick control of the disease can be achieved (by use of 'O' monovalent vaccine) in those areas where serotype O is mostly prevalent and serotypes A and Asia1 are relatively absent (**Action: DAHD&F/ PDFMD/ State AH Department**).
3. Detail research may be undertaken to understand variability in the virulence of different serotypes of FMD virus (**Action: PDFMD)**.
4. Outbreaks of FMD in Zoo/captive animals should be thoroughly studied and the origin of virus causing such outbreaks should be traced. The FMD susceptible animals maintained in the zoo may be vaccinated regularly against FMD (**Action: PDFMD/ Central Zoo Authority)**.
5. Each and every outbreak should be attended and thoroughly investigated by the PI of the concern AICRP centers/network units to collect logical information about source of the virus. No disease incidence has to be declared as FMD outbreak without proper diagnosis and serotyping of the causative virus (**Action: PDFMD/ AICRP Regional Centers/Network Units).**
6. The regional centre of Guwahati has to look after all the five network units in the North East (Mizoram, Manipur, Nagaland, Tripura and Arunachal Pradesh) (**Action: PDFMD/AICRP Regional Center Guwahati/Network Units of North East State).**
7. The data for calculation of economic loss due to FMD outbreak has to be collected by all AICRP centers and network Units as per the model developed by NCAP, New Delhi (**Action: PDFMD/ NCAP/ AICRP Regional Centers/Network Units).**
8. The dynamics of FMD virus circulation has to be investigated in North East and West Bengal. A geography specific research project has to be prepared (to understand circulation dynamics, ecology and habitat, and nucleus/source of infection as all the three serotypes are prevalent) by Dr. R. Sharma, I/C Regional Center, Hisar in consultation with Dr. K Sharma, Dr. R. Venkatramanan, Dr. Animesh Sikdar, and Scientists of PDFMD at the earliest and submitted to ADG (AH) for thorough discussion and early initiation of the study (**Action: PDFMD/ AICRP Regional Centers Hisar, Guwahati, Kolkata/JD IVRI Bangalore).**
9. The telecommunication and internet facilities at all the AICRP regional centers and network units have to be strengthened for better communication with the field/block level veterinarians for scouting of the outbreaks, coordination with PDFMD and neighborhood state and interstate animal disease

diagnosis laboratory (**Action: PDFMD/ AICRP Regional Centers/Network Units).**

10. All clinical materials collected for diagnosis must be sent to the central FMD laboratory at Mukteswar (**Action: PDFMD/ AICRP Regional Centers/Network Units).**
11. One needle per animal to be used during vaccination to check the possible spread of virus during vaccination **(Action: DAHD&F/State AH Departments**).
12. The PI of each center/ network units should specify the percentage of time devoted or contributed for FMD related work (**Action: PDFMD/ AICRP Regional Centers/Network Units).**

Administrative

1. Preventive vaccination Programme should be chalked out in consultation with DADF GoI, in relation to time and density of vaccine, neighborhood state vulnerability, quality of vaccine and availability of vaccine doses (**Action: ICAR/ DAHD&F/State AH Departments /PDFMD/ AICRP Regional Centers/Network Units).**
2. National FMD Control Commission may be constituted, as followed in other countries, for effective and time bound control of FMD in India (**Action: ICAR).**
3. Research Associates (as approved in XI Plan EFC) has to be provided to the regional centers and network units of Pune, Kolkata, Ranipet, Bhopal, Kerala, Hisar through central deployment from PDFMD as these centers are unable to recruit due to local administrative problems (**Action: ICAR/ PDFMD).**
4. ELISA reader should be made available to the Regional Center Pune, and Network Units of Agartala, Imphal and Panta (**Action: ICAR/PDFMD).**
5. The vaccination against FMD in the interstate border districts should be intensified to check transmission of the virus through migratory animals (**Action: DAHD&F/State AH Departments /PDFMD/ AICRP Regional Centers/Network Units).**
6. A mechanism has to be developed in the line that followed in Haryana for certification of interstate movement of animals across the state boundary (**Action: DAHD&F/State AH Departments).**
7. Proposal has to be included in the 12th plan to provide vehicle to all the AICRP network units of North East states and Jammu keeping in view of the geotopological conditions of these states for smooth epidemiological studies of FMD in these areas (**Action: ICAR/PDFMD).**
8. Functioning of the Network Unit, Patna has to be further strengthened in consultation with the Hon'ble Vice Chancellor of Bihar Agricultural University, Secretary and Director of AH department of Bihar (**Action: PDFMD).**
9. It was noted that Network Unit of Itanagar, Arunachal Pradesh is neither submitting their reports (monthly, half yearly and annual) in time nor participated in the 22nd Annual Review Meeting without showing any valid reason which was viewed seriously by the chairman and it was suggested that the project director may take necessary steps for revamping of the network unit in consultation with the secretary and Director of the state AH department (**Action: PDFMD).**
10. In 12th plan emphasis has to be given for setting network units in Sikkim, Uttarakhand, Jharkhand, Chhattisgarh, Andaman & Nicobar Islands and Goa to expand epidemiological investigations (**Action: PDFMD).**
11. Each Regional Center/Network Unit should revalidate their balance amount, if any, of the previous years immediately from the PDFMD (**Action: PDFMD/ AICRP Regional Centers/ Network Units).**

13.0

Publications

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1. Manoranjan Rout, Aniket Sanyal, Saravanan Subramaniam, Bana Bihari Dash, Jyoti Misri, K.M.L. Pathak and Bramhadev Pattnaik. (2012). Foot and Mouth Disease: A Threat to Livestock Health, Productivity and Food Security. **Indian Farming. 61(11):** 3-6, February 2012.
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2. J. K. Biswal, G.K. Sharma, R. Ranjan**,** A. Sanyal, J Misri, G Prasad and B. Pattnaik (2012). Necessity of landscape genetics for control and eradication of FMD in India. FAO-ICAR International Conference on **Scientific developments and technical challenges in the progressive control of Foot and Mouth Disease in South Asia** at New Delhi, India, 13- 15 February 2012, pp 30- 31.
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6. Basavaraj S. Mathapati, Saravanan Subramaniam**,** Biswajit Das, Aniket Sanyal and Bramhadev Pattnaik. Recombination in structural and non structural protein coding region of Foot-and–mouth disease serotype O Indian isolates. XX National Conference **of** Indian Virological Society on **"Managing Emerging and Re-emerging Plant, Animal, Human and Aquatic Viral Diseases: One Health Perspective"** 29-31 December 2011, Haryana, India.
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5. Subramaniam. S, Mohapatra. J.K, Sanyal. A, Pattnaik B (2012). Emergence and re-emergence of different genotypes/lineages in India. FAO-ICAR International conference on **scientific developments and technical challenges in the progressive control of Foot-and-Mouth Disease in South Asia**. February 13-15, 2012, New Delhi.
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Diagnostic manual/bulletin

Manual on Laboratory training on foot and mouth disease diagnosis for 'Laboratory Training on FMD Diagnosis for SAARC Member Countries' held at Project Directorate on Foot and Mouth Disease, Mukteswar from May 2- 7, 2011.

14.0

Human Resource Development

Participation in Meetings/Conference/ Symposium/Training

1. Scientists' participated in the International conference on "**Scientific Developments and Technical Challenges in the Progressive Control of FMD in South Asia**" held from 13th-15th February' 2012, at NASC, ICAR, New Delhi
2. Scientists' participated ICAR-sponsored short-term training under Niche Area of Excellence on **"Recent Advances in Disease Diagnosis of Livestock"** organized at IVRI Campus, Mukteswar from 22nd February to 2nd March' 2012
3. Scientists' participated in National Workshop on **"Frugal Innovations for Sustainable Solutions in Fisheries and Agricultural Sectors"** organized at National Bureau of Fish Genetic Resources (NBFGR), Lucknow on 24th March' 2012
4. Scientists' participated inVIROCON-2011: **Managing Emerging and Re-emerging Plant, Animal, Human and Aquatic Viral Disease: One health perspective**. December 29-31, 2011, Hisar

Foreign Deputation

1. Dr. J.K.Mohapatra was deputed to participate in a six month training at PIADC, USA under the collaborative project entitled "Antigenic and genetic characterization of Foot-and-Mouth Disease Virus in India: application to effective molecular vaccines" between ICAR, India and USDA, USA from 11-5-2011 to 14-11-2011.
2. Dr. Aniket Sanyal was deputed to provide training on FMD diagnosis and epidemiology at the National Center for Animal Health (NCAH), Serbithang, Thimpu, Bhutan from 2-16 November 2011
3. Dr. Bana.B.Dash attended the FAO organized 'laboratory information management systems: workshop to identifying needs, resources and ways forward' from 8-9 December in Phuket, Thailand.
4. Dr. Bramhadev Pattnaik and Saravanan Subramaniam participated in FAO sponsored Workshop on Laboratory Networking and Proficiency Testing for Priority HPEDs in SAARC Countries held at Dhaka, Bangladesh from 23-24 January, 2012

Education and Training

The Scientists of PD FMD are involved in teaching various courses for the M.V. Sc., and Ph.D. students of Division of Veterinary Virology for their degree at Indian Veterinary Research Institute. During the year the following courses were offered by the scientists of the project: Viral Pathogenesis, Immunity to Viral Infection, Viral vaccines, Diagnostic Virology, Virological Technique, Advanced Virological Technique, Slow Viruses and Virus like agents, Advanced General Virology, Avian viruses. Five students completed their PhD dissertation work in Veterinary Virology and one student in MV.Sc Veterinary Virology at central laboratory of the Project Directorate on FMD.

S. No.	Name of the students and institute	Title of the Research Work	For Degree
1.	Dr. G.K. Sharma, IVRI Deemed University, Izatnagar	Development of immunoassays for differentiation of foot and mouth disease infected and vaccinated animals.	PhD in Veterinary Virology
2.	Dr. Basavraj Mathapathi, IVRI Deemed University, Izatnagar	Assessment of antigenic and genetic variation in serotype O foot and mouth disease virus in India: antigenic cartography and complete genome sequence analysis.	PhD in Veterinary Virology
3.	Dr. Sachin D. Audrya, IVRI Deemed University, Izatnagar	Cytokine expression in foot and mouth disease virus infection and vaccination	PhD in Veterinary Virology

S. No.	Name of the students and institute	Title of the Research Work	For Degree
4.	Dr. Sonalika Mahajan, IVRI Deemed University, Izatnagar	Development of recombinant non-structural protein 2C and 3D based indirect ELISA for Foot and Mouth Disease sero-surveillance	MVSc in Veterinary Virology
5.	Mr. Piyush Kumar Gupta Department of Biotechnology Kumaun University Bhimtal Campus	Genetic characterization of 3A gene of Foot and Mouth Disease Virus Serotype Asia 1field isolates	MSc in Biotechnology
6.	Mr. Abhinendra Kumar Department of Biotechnology Kumaun University Bhimtal Campus	Genetic characterization of P1 region of Foot and Mouth Disease Virus Serotype Asia 1field isolates	MSc in Biotechnology

Training organized

Eleven training Programmes on sandwich ELISA, LPBELISA and DIVA were organized, in which scientists from network units/regional centres and three scientists from FMD vaccine manufacturing companies, and SAARC countries participated.

Date	Venue of training	Subject of training	Supplier of the training	Recipient of the training
SAARC Countries Training Programme				
2/5/11 to 7/5/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	Animal virus laboratory, Sri Lanka
2/5/11 to 7/5/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	National centre for animal health, Bhutan
2/5/11 to 7/5/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	National Agricultural research center, Pakistan
2/5/11 to 7/5/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	Department of livestock services, Nepal (2)
2/5/11 to 7/5/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	Central veterinary investigation center, Sri Lanka (1)
2/5/11 to 7/5/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	National center for aninmal health, Bhutan
20/6/11 to 25/6/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	Livestock research institute, Bangladesh
20/6/11 to 25/6/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	FMD vaccine production laboratory, Bangladesh
20/6/11 to 25/6/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	National FMD and TAD laboratory , Nepal
National Training Programmes				
2/5/11 to 7/5/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	RRC on FMD, Hisar, India
18/07/11 to 23/7/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	FMD Regional centre, Maharashtra, India (2)
25/08/11 to 30/8/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	CARI, A & N Island, India(2)
29/08/11 to 3/9/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	FMD Network Unit, Gujarat, India(2)

Date	Venue of training	Subject of training	Supplier of the training	Recipient of the training
27/10/11 to 31/10/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	FMD Network Unit, Nagaland, India
12/12/11 to 15/12/11	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	FMD Network Unit, Kerala, India(2)
09/01/12 to 13/1/12	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	FMD Regional centre, Tamilnadu, India (2)
12/03/12 to 17/3/12	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	FMD Regional centre, Karnataka, India
11/03/12 to 17/3/12	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	CARI, A & N Island, India
12/03/12 to 17/3/12	Central laboratory, Mukteswar	LPBELISA, DIVA and Sandwich ELISA	PDFMD	FMD Network Unit, Odisha, India

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