ANNUAL REPORT
2018-19

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

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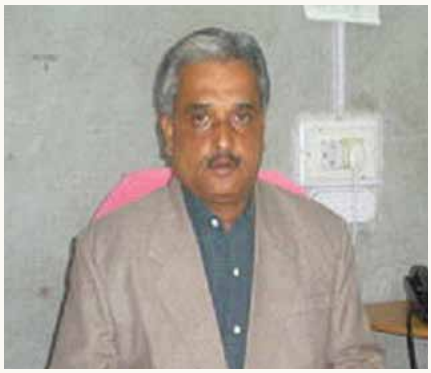
Foreword



Foot and mouth disease (FMD) remains a serious threat to the livestock populations, primarily cattle and buffaloes of India. FMD is on the A list of infectious diseases of animals of the Office International des E´pizooties (OIE). The disease affects all cloven footed domestic and wild animals including bovids (cattle, zebus, buffaloes, yaks), sheep, goats, pigs, African buffalo (*Syncerus caffer*), bison (*Bison* spp.), elk, moose, chamois, giraffes, blackbuck, warthogs, kudu, impala, and several species of deer, antelopes and gazelles. The causative agent, FMD Virus (FMDV) belongs to genus *Aphthovirus* in the family *Picornaviridae*. The virus occurs as seven genetically and antigenically distinct serotypes (O, A, C, Asia1 and Southern African Territories (SAT) 1-3) and multiple subtypes. The earliest record of FMD in the country dates back to 1864 when it occurred in many parts of the country (Records of the Government of India, 1868). All the four Euro Asian serotypes (O, A, C and Asia1) has been recorded. Serotype O is the most dominating one followed by serotypes Asia1 and A. Serotype C has not been encountered in India since 1995.

FMD surveillance in India is being carried out by 27 regional and collaborating centers span across the country and ICFMD at Bhubaneswar. All the activities of these laboratories are coordinated under the All India Coordinated Research Project (AICRP) for FMD. Serotyping of the clinical materials collected from the suspected outbreaks/cases is conducted by the network laboratories using sandwich ELISA and clinical samples are forwarded to ICFMD for further characterization. ELISA negative samples are subjected to multiplex PCR for diagnosis. Molecular epidemiological analysis based on P1/1D gene sequence and studies of antigenic relationship of the field outbreak strains with currently used vaccine strains to monitor antigenic variation, if any, occurring in the field is carried out regularly. The ICAR-DFMD and its AICRP component are involved in gathering real time epidemiological information and developing companion diagnostics for FMD since 1968.The institute has been providing all the technical/ laboratory and diagnostic support to the FMD control programme (FMDCP) being run by DAHD, Govt. of India since 2003-04.

I am happy to share that ICAR-DFMD is a member of the Global FAO/ OIE Network of FMD Reference Laboratories that constitutes of ten other FMD laboratories in the world. The institute also functions as the FAO-FMD Reference Center and SAARC Regional Leading Diagnostic Laboratory for FMD. The institute is also a member of GFRA (Global FMD Research Alliance). The state-of-the-art FMD research centre (ICFMD) with high containment laboratory facility established by ICAR at Bhubaneswar meet the major requirement of FMDCP as stipulated by OIE/ FAO, and will cater to the need of researchers and scientists of India and abroad for safe handling of FMD virus as per international norms. The one-of-its-kind FMD research centre in South Asia, will help analyse exotic FMD virus strains in order to develop preparedness in diagnostics and vaccines to prevent their incursion.

I thank all my fellow scientist colleagues, administrative, accounts and laboratory staff of the institute for their sincere efforts and contribution in accomplishing the tasks assigned to the Institute. The Director and staff of ICAR-DFMD express our deep sense of gratitude to Dr T. Mohapatra, Hon'ble Secretary, DARE & DG, ICAR; Shri B. Pradhan, AS&FA, DARE; Shri C. Roul, Addl. Secretary (DARE) & Secretary, ICAR; Dr J. K. Jena, DDG (AS), ICAR and Dr Ashok Kumar, ADG (AH), ICAR for providing all the necessary financial and infra-structural facilities and providing the guidance. Also, the help and support extended by Dr. Jyoti Misri, Principal Scientist (AH) Dr.Vineet Bhasin, Principal Scientist (AGB) and Dr. Ranjan Gupta, Principal Scientist (ANP) is acknowledged.Untiring effort of a small group of young scientists in achieving new milestones at the institute is praiseworthy.

B Pattnaik

1 Executive Summary

During the year 2018-19 (Tables 1& 2), a total 391 outbreaks of FMD were recorded in the country. Almost 56 % of the outbreaks were in the southern region of the country, and 62 % of the incidences were in the state of Karnataka. During the period, disease was recorded in many states and also UTs like Pudduchery and A&N Islands. FMD appeared in the A&N Islands after a gap of almost 13 years. There were no outbreaks in Andhra Pradesh, Mizoram and Arunachal Pradesh.

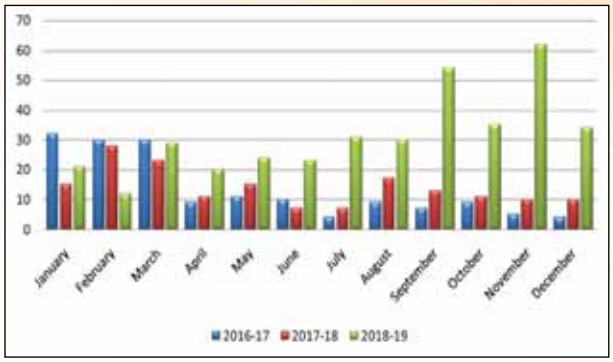


Fig. 1: Monthly incidence of FMD (2016-17 to 2018-19)

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

Year	South	North	Central	West	East	North East	Total
2014-15	10	4	10	3	25	24	76
2015-16	89	18	26	23	44	52	252
2016-17	49	11	05	06	22	57	150
2017-18	101	17	-	10	-	21	149
2018-19	219	37	05	27	82	21	391

The serotype O continued to be most predominant one and was responsible for 99% of the outbreaks recorded during 2018-19. The serotype Asia1 was recorded in the state of West Bengal and Assam. After a period of almost three years, serotype A was recorded in the country in the state of Maharashtra.

Table 2: Year wise outbreaks of FMD and virus serotypes involved during last 5 years.

Year	No. of outbreaks	O	A	Asia1
2014-15	76	75	0	01
2015-16	252	244	06	02
2016-17	150	150	0	0
2017-18	149	146	0	03
2018-19	391	386	01	04

Outbreaks of FMD were recorded throughout the year. Maximum outbreaks of FMD were recorded during September to December.

Vaccine matching exercise was carried out to evaluate antigenic relationship of field isolates with currently used vaccine strains to monitor antigenic variation, if any, occurring in the field, and to assess appropriateness of in-use vaccine strains. A total of 37 serotype O were antigenically characterized during the period. The field situation suggested majority of the isolates were antigenically homologous to currently used vaccine strain INDR2/1975. The isolates of serotype Asia1 also antigencially covered by currently used vaccine strain IND63/1972. To circumvent emergence of antigenically divergent in VP3[59]-deletion group strains of serotype A, an alternate vaccine candidate strain (A IND 27/2011, isolated from a bullock of Chikkaballapur district, Karnataka) has been identified for replacement of the existing vaccine strain A IND 40/2000 to maintain the vaccine efficacy and is ready for inclusion in vaccine formulation.

Phylogenetic analysis based on P1/VP1coding

region was carried out to assess genetic variations/ mutations/recombination, inter-strain relationships and track movement of the virus. During the period, capsid coding region (P1/VP1) sequences of 92 FMD virus strains were deduced and were added to the sequence database of Indian FMD viruses. Analysis of these data led to many important phylogenetic inferences for understanding molecular epidemiology of FMD. During the year, phylogenetic analysis of serotype O virus revealed extended and exclusive dominance of lineage Ind2001 strains. The lineage Ind2001 has been dominating the scenario since the year 2008 with emergence of sub-lineage Ind2001d in 2008 and sub-lineage Ind2001e in 2016. The details are presented later.

National FMD Virus Repository was upgraded with new virus isolates. The virus repository has served the cause of the country by providing isolates for molecular epidemiological studies, evaluation of antigenic relatedness between the field and vaccine strains and selection of new candidate vaccine strains whenever required. A total of 91 serotype O virus isolates were added to the repository during the reported period (Table 7.1). At present the National FMD virus Repository holds a total of 2278 isolates (O-1574, A-323, C-15 and Asia 1-366).

Under FMDCP seromonitoring to assess the effectiveness of vaccination a total of 2,31,983 serum samples were tested using SPCE (6,95,949 tests). Up to 2018-19, 12, 34, 420 serum samples collected under FMDCP were tested for estimation protective antibody level against each of the three serotypes (O, A and Asia1). In this process of a total of about 37, 03,260 tested were conducted and results were communicated to DAHD.

Under National FMD Serosurveillance, 51,485 bovine serum samples collected at random from various parts of the country were tested in r3AB3 NSP-ELISA (DIVA) for assessing the prevalence of NSP-antibody (NSP-Ab) positive animals, which is an indicator of FMD virus exposure regardless of vaccination status and virus circulation. The test revealed overall seropositivity in 20.02% samples/ animals, which is comparatively lesser than the previous year's average of 21.2%

Vision, Mission, Mandate, Objectives and Technical Programme

2

Vision:

India free from Foot and Mouth Disease.

Mission:

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

Mandate:

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

Objectives:

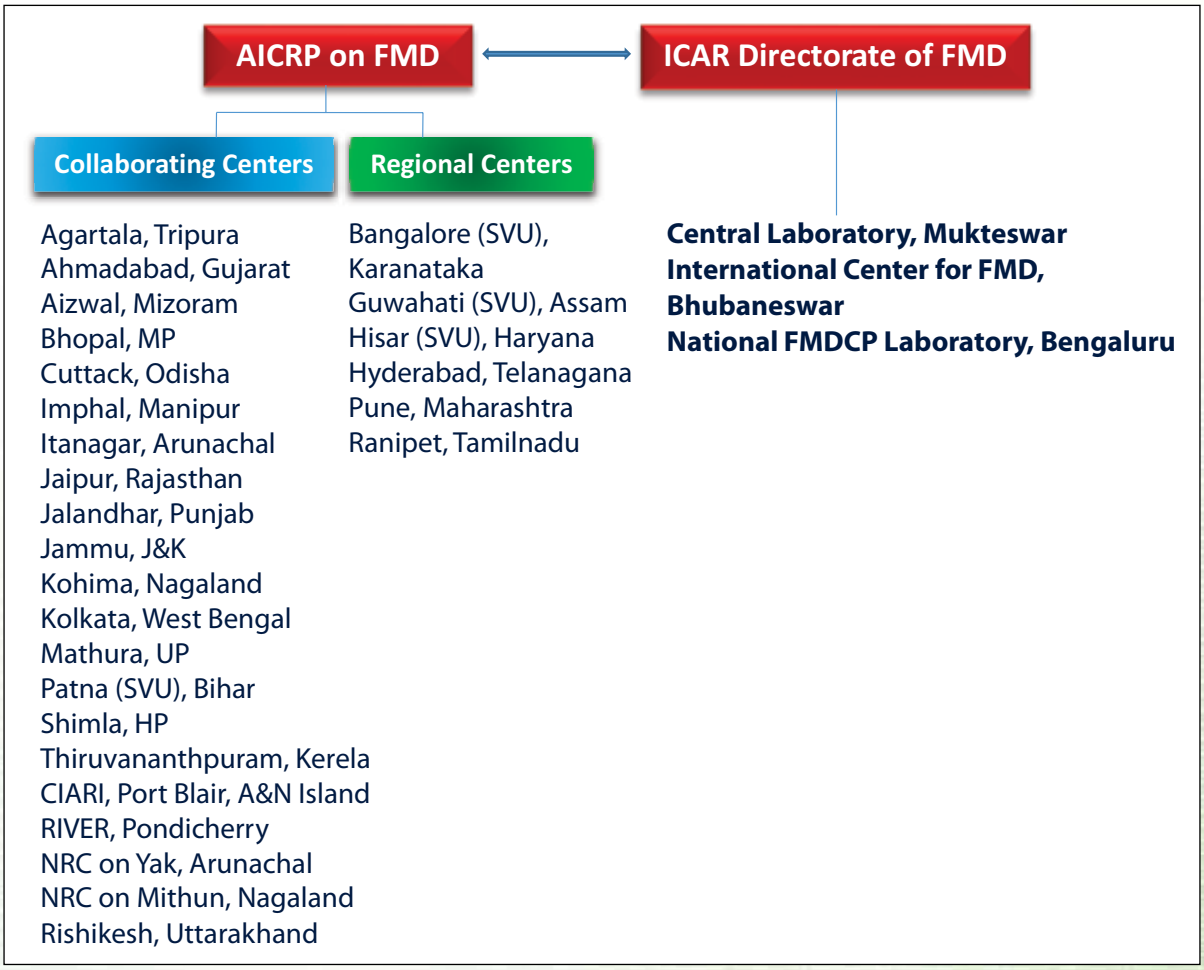
1. To conduct systematic epidemiological and molecular epidemiological studies on Foot-and- Mouth Disease (FMD), and also to study carrier status of the infection and latency of the virus.
2. Antigenic and molecular characterization and cataloguing of FMD virus strains isolated from incidences, and monitoring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

Technical Programme:

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

3 Organizational Setup

The ICAR-Directorate of Foot and Mouth Disease (FMD), the premier institute for FMD in the country, was established as an All India Coordinated Research Project (AICRP) for FMD in 1968. During about five decades of its existence the scope of the project has been expanded progressively and several milestones were achieved. The AICRP for epidemiological studies on FMD was upgraded to the Project Directorate on FMD in July 2000 and then renamed as Directorate of FMD since 2015-16 with 27 Regional and Collaborating centres covering all the major regions of the country. The Directorate has developed scientific expertise in conventional as well as in cutting edge areas, in the field of FMD diagnosis, epidemiology and research. The mandate of the institute is to carry out research on the epidemiology of FMD in the country and develop technologies to control the disease with ultimate goal of eradication. It is also entrusted with the duty of providing technical support and scientific input/information to the planners and strategy making agencies in planning control of FMD in the country and the SAARC region. The new addition to the institute is the **International Centre for FMD (ICFMD)** at Bhubaneswar that encompasses both BSL-2 and BSL-3Ag high containment laboratories.



Epidemiology and Surveillance

4

Table 4.1 FMD outbreaks recorded and diagnosed during 2018-19 and virus serotype(s) involved

States	Reporting Centre	No. of. FMD outbreaks	No. of. Samples tested	Virus Serotypes		
				O	A	Asia1
Southern Region						
Andhra Pradesh	Vijayawada	No outbreak				
Telangana	ICFMD	03	21	03(03)	-	-
Tamil Nadu	Ranipet	43	381	43(71)	-	-
Karnataka	Bangalore	135	586	244(135)	-	-
Kerala	Thiruvanthapuram	36	429	36(99)	-	-
Puducherry	Puducherry	01	04	1(4)	-	-
Andaman & Nicobar	Port Blair	01	38	1(9)	-	-
Total		**219**	**1459**	**219(321)**	**-**	**-**
Northern Region						
Haryana	Hisar	06	26	06(25)	-	-
Delhi	Hisar	01	02	01(01)	-	-
Himachal Pradesh	Shimla	05	48	05(05)	-	-
Jammu & Kashmir	Jammu	12	60	12(12)	-	-
Punjab	Jalandhar	08	22	08(20)	-	-
Uttar Pradesh	DFMD	03	20	03(04)	-	-
Uttarakhand	DFMD	02	53	02(06)	-	-
Total		**37**	**232**	**37(73)**	**-**	**-**
Central Region						
Madhya Pradesh	Bhopal	04	27	04(16)	-	-
Chhattisgarh	ICFMD	01	16	01(01)	-	-
Total		**05**	**43**	**05(17)**	**-**	**-**
Western Region						
Gujarat	Ahmadabad	06	29	06(11)	-	-
Maharashtra	ICFMD	16	169	15(36)	01(02)	-
Rajasthan	Jaipur	04	51	04(04)	-	-
Goa	ICFMD	01	09	01(05)	-	-
Total		**27**	**258**	**26(56)**	**01(02)**	**-**
Eastern Region						
West Bengal	Kolkata	61	301	58(189)	-	03(08)
Bihar	Patna	13	22	13(13)	-	-

States	Reporting Centre	No. of. FMD outbreaks	No. of. Samples tested	Virus Serotypes		
				O	A	Asia1
Odisha	Cuttack	08	08	08(08)	-	-
Total		**82**	**331**	**79(210)**	**-**	**03(08)**
North Eastern Region						
Assam	Guwahati	11	18	10(17)	-	01(01)
Tripura		01	04	01(01)	-	-
Meghalaya	Shillong	08	34	08(23)	-	-
Mizoram	Aizwal	No outbreak				
Nagaland	NRC Mithun	01	11	01(01)	-	-
Arunachal	Itanagar	No outbreak				
Total		**20**	**66**	**20(42)**	**-**	**-**
Grand Total		**391**	**2390**	**386 (719)**	**01(02)**	**04(09)**

Number of samples collected from FMD suspected cases is given in parenthesis. More than one clinical material was collected from many cases and send to DFMD and ICFMD by respective centres.

4.1 Southern Region

Southern region comprises of five states (Tamilnadu, Karnataka, Telanagana, Andhra Pradesh and Kerala) and about 21% of the FMD susceptible livestock of the country. The region shares no international border and the state of Karnataka is found to be hyperendemic area for FMD. The entire southern peninsular region has been covered under FMDCP since the year 2010-11. No incidence of FMD was reported from the state of Andhra Pradesh

Telangana: Three FMD outbreaks were recorded in the state and all of them were caused by serotype O. One outbreak was recorded in Bison in Nehru Zoological Park Hyderabad and Two outbreaks were recorded in the district of Nagarkurnool. All the three outbreaks were recorded in the month of September'2018.

Tamilnadu: During the year, 43 outbreaks due to serotype O were recorded in the state. Maximum of 32 outbreaks were occurred in the month of Nov'2018 which indicates the incidences probably originated from single foci and transmitted rapidly by animal movement. Besides, outbreak were occurred in the months of July'2018 (n=2), October'2018 (n=2), December'2018 (n=6) and January'2019 (n=1). Maximum number of outbreaks (n=23) were reported from the district of Erode where large cattle shandies operate regulalry and remaining were recorded in the adjacent districts including Salem, Namakkal, Trippur and Coimbatore. This further reiterates the fact that the majority of the incidences were epidemiologically linked.

Karnataka: During the year, 135 FMD outbreaks were reported in the state. All of them were caused by serotype O. The outbreaks occurred throughout the year with maximum in Novemeber'2018 (n=19) followed by October'2018 (n=15), December'2018 (n=14), September'2018 (n=13), April'2018 (n=13), August'2018 (n=12), May'2018 (n=10), June'2018 (n=10), July'2018 (n=9), March'2018 (n=8), January'2019 (n=8) and February'2019 (n=4).The incidences were widespread and reported from many districts. Maximum numbers of outbreaks were recorded in Ramanagara (n=30), Tumkur (n=22), Bengalrur rural (n=19), Bengaluru Urban (n=19) and Chikballapura (12). Outbreaks were also recorded in Kolar (n=6), Mandya (n=6), Chikmangalore (n=5), Mysuru (n=1), Dharward (n=4), Davangere (n=2), Vijayapura (n=1), Raichuru (n=3), Chitradurga (n=1), Udupi (n=1), Shivamoga (n=1) and Hassan (n=2).Majority of the incidences were epidemiologically linked, appears to be extension from a single incidence.

Kerala: During the period, a total of 36 FMD outbreaks were recorded in the state. FMDV serotype O caused all the incidences. The disease was recorded in almost all districts of the state including Alappuzha, Ernakulam, Idukki, Kannur, Kasargod, Kollam, Kottayam, Kozhikode, Malappuram, Pathanamthitta, Trivandrum, Thrissur and Wayanad. The outbreaks were recorded throughout the year during the months of April'2018 (n=3), May'2018 (n=2), June'2018 (n=4), July'2018 (n=5), August'2018 (n=3), September'2018 (n=5), October'2018 (n=3). The disease was recorded in cattle, buffalo, goat, pig and also in captive elephant.

Pondicherry (UT): One outbreak was recorded in the month of December'2018 in Pondicherry

Andaman & Nicobar Islands (UT): In May'2018, FMD appeared in the island after a gap of almost 13 years. Last FMD outbreak was recorded in March'2005 following tsunami. The disease was first reported in the cross-bred cattle Port Blair city showing typical lesion and symptoms of FMD. Gradually the disease spread to other parts of the South Andaman villages in the radius of approximately 35 km zone. In the present outbreak a total of 465 cattle, 15 buffaloes and 385 goats were affected due to FMD. The morbidity was found to be 85 to 90 %, however, the mortality was found to be less than 2 %. The spread of the disease to the adjoining villages did not show any systematic pattern. However, the spread was random and at the same time the disease was reported from different areas of the South Andaman district. Due to the geographical isolation and separation the outbreak was confined to only South Andaman district. The movement of the animals in this island

is generally from North and Middle Andaman to South Andaman, which might be the reason for confinement of the disease in the South Andaman district only.

The herd immunity after the latest round of FMDCP was found to be only 41 %(Type O), 38 % (Type A) and 44 % (Type Asia-1). The level of poor vaccinal antibody tire might have played a key role in disease spread. During the last 15 years there has not been any transport of animals from mainland to islands. Therefore the reasons for the present outbreak might be due to the entry of virus through paddy straws which are being used as packing materials for transport of vegetable and fruits. The first case of the present outbreak was also reported from the city, wherein the stray cattle might have eaten the contaminated paddy straw and exposed to the virus.

4.2 Central Region

Central region comprises of two states (Madhya Pradesh and Chhattisgarh) and about 10% of the FMD susceptible livestock of the country. The region shares no international border. The entire central region is covered under FMDCP.

Madhya Pradesh: During the period under report, the state recorded four FMD outbreaks in the months of September'2018, October'2018 (n=2) and January'2019. The state was free from FMD during 2017-18. Two outbreaks were essentially reported from unvaccinated animals. Two outbreaks were reported from district of Chhindwara and one each from Dist. Vidisha and Military Dairy Farm, Jabalpur. The incidences occurred in cattle and all of them were caused by serotype O.

Chhattisgarh: One outbreak was recorded in the state in the month of October'2018. The

disease occurred in Dhamtari district and caused by serotype O.

4.3 Western Region

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

Gujarat: During the year, six outbreaks of FMD were recorded, one each in the months of April'2018, March'2018, July'2018, August'2018, February'2019 and January'2019 and all of them were caused by serotype O. The incidences were recorded in the districts of Kheda, Ahmedabad, Banaskantha, Tapi and Rajkot (n=2). The incidences were recorded in cattle and buffalo.

Rajasthan: Four outbreaks of FMD were recorded in the during the period. The outbreaks were recorded districts of Udaipur in June'2018, Dausa in September'2018, Jaipur in October'2018 and Churu in January'2019. All the outbreaks were caused by serotype O.

Maharashtra: During the period, sixteen FMD outbreaks were recorded in the state. Serotype O was responsible for fifteen outbreaks and serotype A caused one outbreak. Maximum outbreaks were recorded in the month of March'2019 (n=8) followed by January'2019 (n=4), December'2018 (n=2) and November'2018 (n=1). Highest number of outbreaks were recorded in the district of Ahmednagar (n=9) followed by Beed (n=2) and one each in Solapur, Sangali, Gondia and Military Farm, Pimpri. The outbreak due to serotype A was recorded in Satara district in January'2019.

Goa: One outbreak due to serotype O was recorded in Old Goa

4.4 Northern Region

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

Haryana: During the year, six outbreaks of FMD were recorded in the state and all of them were caused by serotype O. The outbreaks were recorded in the months of March'2018 (n=3), February'2018 (n=2) and September'2018 (n=1). Two outbreaks each were recorded in Hisar and Kurukshtra districts, and one outbreak each was recorded in Kaithal and Karnal districts. Two of the incidences were recorded in organized dairy and pig farm. The species affected includes cattle, buffalo and pigs.

Delhi: In the month of March'2018, one outbreak was recorded in Delhi affecting cattle alone. The disease was caused by serotype O.

Punjab: The state reported eight FMD outbreaks during the period and all of them were caused by serotype O. Three outbreaks were recorded in January'2019 and five occurred in February'2019. The outbreaks were recorded in the districts of Rupnagar (n=3), SAS nagar (n=3), Gurdaspur (n=1) and Tarn Taran (n=1). The disease occurred in cattle and buffalo.

Himachal Pradesh: Five outbreaks were recorded in the state caused by FMDV serotype O. The incidences were recorded in the months of March'2018 (n=2), April'2018 (n=1), June'2018 (n=1) and December'2018 (n=1) in the districts of Sirmour, Una, Shimla, Kullu and Kangra. The disease occurred in bovine and ovine species.

Jammu & Kashmir: During the period, twelve outbreaks were recorded due to serotype O. The outbreaks were recorded in Anantnag (n=3), Baramulla (n=3), Jammu (n=2), Pulwama (n=2), Samba (n=1) and Ganderbal (n=1). Most of the outbreaks occurred in the month of July'2018 (n=5) and May, 2018 (n=4). Further two outbreaks were recorded in March'2018 and one in November'2018. The disease occurred in bovine species

Uttarakhand: Two outbreaks of FMD was recorded, and caused by serotype O. The disease was reported from Almora and Bageshwar in May'2018 and August'2018, respectively.

Uttar Pradesh: Three outbreaks due to serotype O were recorded in Allahabad districts. The outbreaks were recorded in the months of August'2018 (n=2) and September'2018 (n=1)

4.5 Eastern Region

Eastern region comprises of four states (West Bengal, Odisha, Bihar and Jharkhand) and about 22% of the FMD susceptible livestock of the country. **This region shares international border with Bangladesh and Nepal**. The entire region is covered under FMDCP since 2017.

Odisha: Eight FMD outbreaks of FMD were type confirmed in the state and all of them were caused by serotype O. The outbreaks were recorded in the months of March'2018 (n=1), April'2018 (n=1), June'2018 (n=2), August'2018 (n=1) and September'2018 (n=3). The outbreaks were recorded in the districts of Cuttack (n=3), Puri (n=2), Sambalpur (n=2) and Balasore (n=1). The disease occurred in bovine species

West Bengal: During the period, sixty one FMD outbreaks were recorded in the state. Out of which 58 outbreaks were caused by serotype O and 3 were due to serotype Asia1. The outbreaks were recorded throughout the year with maximum during September'2018 (n=13) followed by August'2018 (n=10), December'2018 (n=10), October'2018 (n=9), July'2018 (n=7), November'2018 (n=5), June'2018 (n=3), March'2018 (n=2) and February'2018 (n=2). The incidences were wide spread and recorded in Paschim medinipur (n=13), Bankura (n=8), Howrah (n=7), Nadia (n=6), Hooghly (n=6), Uttar Dinajpur (n=4), North 24 Paraganas (n=3), South 24 Paraganas (n=3), Purba Burdwan (n=2), Purba medinipur (n=2), P.Bardhman (n=2), Jalpaiguri (n=2), Kalimpong (n=1) and Kolkata (n=1). Besides field, the outbreaks were also recorded in organised dairy farms, national park and zoological garden

Bihar: During the period 13 FMD outbreaks were recorded in the state, of which 12 were recorded in the month of September'2018 and one occurred during October'2018. Maximum numbers of outbreaks occurred in the districts of Patna (n=8), Saran (n=2), Bhojpur (n=1), Vaishali (n=1) and Nawada (n=1). All the outbreaks were caused by serotype O and recorded in cattle and buffalo.

4.6 North Eastern Region

North eastern region comprises of seven states (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura) and about 6% of the FMD susceptible livestock of the country. This region shares international border with China, Myanmar, Bangladesh and Bhutan. **No FMD was reported during the period in the state of Arunachal Pradesh and Mizoram**.

Meghalaya: Eight outbreaks of FMD caused by serotype O was recorded in cattle during the period. Six outbreaks were recorded in East Khasi districts and two were recorded in South west Garo hills. Maximum numbers of outbreaks were recorded in the months of November'2018 (n=3), January'2019 (n=2), April'2018 (n=1), September'2018 (n=1) and October'2018 (n=1).

Nagaland: During the year, one outbreak of FMD was recorded in the state caused by serotype O. The incidences were recorded in the districts of Phek district in the month of July'2018

Assam: Eleven outbreaks of FMD were recorded in the state during the period. Serotype O accounted for ten outbreaks and serotype Asia1 caused one outbreak. The disease was recorded in cattle and sheep. Maximum incidences occurred in May'2018 (n=6) followed by June'2018 (n=2), March'2018 (n=1) and July'2018 (n=1). The outbreaks were recorded in the districts of Kamrup (n=3), Darrang (n=3), Jorhat (n=1), Dibrugarh (n=1) and Bongaigaon (n=1).

Tripura: One outbreak due to serotype O affecting pig was confirmed in the state. The incidence occurred in the month of November'2018 in Agartala districts.

Epidemiological Investigation of FMD outbreak in Dharwad district, Karnataka

National Investigation team was assigned a task of investigating FMD outbreak in an organized farm at Dharward.

The private dairy unit is located about 6-7 km on the outskirts of Dharwad. It is a mixed farm comprised of mainly cattle, along with buffalo and goat. The farm has about 1000 cattle (630 cows, 300 heifers and 70 calves), 340 buffalo (300 adults and heifers, and 40 calves) and 300 Goat. It is an organized farm and well maintained with adequate veterinary care. The farm has large number of HF cattle with over 90% HF blood. The farm has a mixed population of cattle, buffalo and goat, housed in the same farm but in separate enclosures.

The cattle and buffaloes in the farm are regularly vaccinated thrice in a year. The cattle and buffaloes were last vaccinated on **22-09-2018**. Goats were not vaccinated.

The disease was first noticed in the farm on **28-09-2018** when a few animals showed clinical symptoms typical of FMD. Following this, there was no fresh case until 3-4 days, after which more number of animals showed disease. Animals showed tongue lesions with ulcers on the gums and limping with lesions on hooves. In some animals lesions were found on the teat also. Tongue lesions were treated with sodium bicarbonate solution while foot lesions were washed with potassium permanganate solution. It was advised to apply Boro-glycerine on oral lesions for fast recovery. Farm was disinfected with disinfectants including VIRKON (Zoetis) and sodium carbonate solution.

Possible sources of infection

As per the information collected, some high yielding milch animals were **taken to Krishi Mela** held at Dharwad for exhibition on **22-09-2018** where a large number of animals of farmers from different parts of the state participated. It was stated that some farmers also visited the farm which could not be verified as no records were available. It was learnt that several **wild pigs which are living** in the close proximity to the farm were spotted apparently suffering from FMD, as limping was reportedly seen in these animals. **Presence of FMD in the neighbouring villages** also was a major risk factor as spread of infection through aerosol to the farm is/ was always possible.

The **outbreak lasted about a month** since the first case (Index case) recorded on 28-09-2018. On the day of team visit also, animals with healed/ healing oral lesions and foot lesions could be noticed. However no fresh cases were observed since **26-10-2018**. Overall, **420 animals were affected** (Calves-70, Cows &Heifer-300, Buffalo-50) with a morbidity rate of 29.8%. Mortality was reported in 9 animals (cattle calves-07, Buffalo calves-01, adult buffalo-01). Reduction in milk yield from herd average of 18 lit per day to 12 lit per day was recorded by the farm causing significant economic loss.

Conclusion and suggestions

Efforts should be made to prevent virus exposure even in vaccinated animals through appropriate and regular biosecurity measures that are needed to be applied along with vaccination in order to check virus transgression from the surroundings. There were several lapses observed in terms of farm biosecurity measures based on the information gathered from the staff. Some of the animals were **sent to Krishimela** on 22-09-18 and disease was observed in the dairy farm on 28-09-18. It is possible that animals got infected at Krishimela and carried the virus to the farm. It was reported that, there was large gathering of animals from many places of the state.

Besides this, ongoing outbreaks of FMD in the surrounding villages were recorded till date (03-11-2018). Clinical materials from the affected animals from Neeralakatti village were collected and handed over to the team during this visit, for lab testing. High number of outbreaks in the district raise the risk of virus exposure even to the vaccinated herds in the neighbouring villages/farms.

Engagement of common animal handlers/ attendants for both sick and healthy animals also facilitated the spread of the infection to a great extent, and this is a serious compromise as far as the biosecurity is concerned. A **Number of wild boars** were reported to roam around the farm premises and workers have noticed limping in these wild pigs (a most common sign of FMD in pigs) although FMD is not confirmed through laboratory tests due to difficulty in collection of samples from these animals. The boars are highly susceptible to FMD and exhale large quantities of the FMD virus in to the air.

The disease is under control as there was no fresh case reported since 26-10-2018, and most of the sick animals were seen recovering from the clinical disease. The shed was disinfected with sodium carbonate solution during the outbreak on the advice of the veterinarians and also Virkon (Zoetis) solution which is also a strong disinfectant. Animals were treated with homeopathic medicines as informed by the owner and antibiotics were also used in some animals but its usage was limited particularly in non-milch animals.

Though Dharwad district is covered under the FMD control program with regular vaccination campaign bi-annually, the extent of vaccination coverage needs to be ascertained by the DAHVS, Karnataka. This is important in view of the high rate of outbreaks this year especially in the villages neighbouring Dairy farm.

The following suggestions were given to the farm authorities

1. Strict biosecurity measures to be executed to prevent the future episodes of infection
2. Sanitary measures to be implemented throughout the year and every day.
3. Vaccination record to be properly maintained along with the vaccine batch and manufactures details and the expiry date etc.
4. All cattle and buffalo above 3 months of age have to be vaccinated. In case of pregnancy/ pregnant animals, one dose of vaccine after Pregnancy Diagnosis at 2-3 months of gestation and then another dose at 6-7 months need to be administered so that the calf is born with maternal antibodies to FMD, in addition to protection of the dam during gestation. Stress due to handling of pregnant animals during vaccination should however be avoided
5. Pre and post vaccination serum samples to be collected for monitoring the level of sero-conversion following vaccination. Serum Samples may be submitted to sero-monitoring laboratory of DFMD at Bangalore for testing immune status of the herd.
6. Segregation of the workers attending different age group of animals, and introduction of mandatory shower and change over system for the animal attendants working in the farm.
7. Visitors including farmers are to be discouraged from visiting the farm.

8. Vaccination of the calves at 3-4 months of age followed by booster dose at 1 month post primo-vaccination. This should be followed by regular vaccination at six months interval
9. Vaccination of small ruminants in the farm.
10. Avoid exposure of animals to Krishimelas, as high yielding cross bred HF animals are highly susceptible to FMD virus infection, despite vaccination status. The animals sent to Krishi Melas are to be quarantined for at least 1 month with engagement of separate animal attendants, before taken back to the main herd. Serum samples of animals before being taken to Krishi Melas have to be collected and preserved, to compare with the serum samples to be collected during post Krishi Mela quarantine.
11. Regular sero-monitoring and DIVA surveillance at 6 months interval.

Epidemiological Investigation of FMD in Hassan district, Karnataka

FMD outbreaks were investigated by the Expert team in different villages of Hassan District, Karnataka.

Possible sources of the outbreak

Most of the outbreaks were sporadic in nature except higher rate incidence in two villages NygereKoppalu (44% morbidity) followed by Ankanahalli, Gorur (morbidity of 11%). On interaction with the farmers/veterinarians it was learnt that the several outbreaks were mostly associated with introduction of fresh stock of animals into the herd on purchase of animals from the surrounding villages.

Movement of animals related animal trade was high in the villages adjoining Ghandsi and Channrayapatna. Ghandsi is the largest animal trade centre in the Hassan district which takes place on each Thursday of the week. Animals from Channraypatna and Arasikere are brought here for sale through mostly by middlemen and partly by farmers themselves. CR Patna is the next big shandy that opens on the following day (Friday each week). Animals that are not traded on the previous day at Ghandsi are also moved here. Shravanbelagola and Hasan are relatively smaller shandy places as compared to Ghandsi or CR Patna, where animals from surrounding villages are brought for sale. Middlemen are actively involved in the trade business and contribute to movement of animals and the disease thereby.

The animals in these villages were vaccinated during June 2018. Higher incidence was observed in HF animals rather than indigenous animals exception (Ulivalu village outbreak where Hallikar bull and cow were found affected with disease). These were freshly purchased by the farmer about 10 days back.

Conclusive remarks/suggestions

The sporadic outbreaks caused by FMDV serotype O, in different villages is indirect indicator of adequate vaccination coverage in the district. However moderate to high severity in two of the villages needs to be investigated properly for vaccination coverage and other associated factors such as movement of animals and climatic factors that might compromise the immune status of animals. However in general, the disease severity in terms of clinical manifestation, duration of clinical signs and morbidity was apparently found to be in subdued form as informed by the vets. Animals showed quicker recovery following the appearance of clinical signs.

Following are some suggestions which may be considered.

- Timely vaccination of animals to be carried out, as delay in the vaccination schedule will lead to higher rate of disease outbreaks as this creates a window of susceptibility.
- Calves (cattle and buffalo) to be vaccinated at the age of 3-4 months followed by booster injections 4 weeks later and then six-monthly vaccination.
- Movement of animals without vaccination status needs to be regulated. This warrants educating the farmers on the disease transmission and risks associated with such activities for the purpose of trade. Active of support of district administration may be sought for effective implementation of the checks on animal movement associated with animal trade. This may include deploying temporary bans on the animal trade during the phase of outbreak on the advice of department (for timing such measures).
- Vaccination coverage: Adequate vaccination coverage is important to build herd immunity as lapses in the coverage for various reasons (related to veterinary services or farmers' refusal to vaccinate his /her animals) could serve as focal point for spread of infection
- Educating the farmers on the risks of introducing the fresh stock without proper history on the disease status or vaccination status needs to be addressed. Farmers refusing vaccination need to be counselled to make them aware of the risks of disease spread and the associated losses. Their awareness on the disease control through vaccination and following proper sanitary measures (including segregation and separate attendant for ailing animals) to be improved through extension works and mass media communication with the help of district administration machinery.

4.7 Molecular epidemiology of FMD

1. FMDV Serotype O

During 2018-19, a total of 92 serotype O FMDV field isolates were subjected to complete 1D/VP1 region sequence analysis. Phylogentic analysis was carried out using different methods including Maximum Likelihood (ML), Neighbour-Joining (NJ) and UPGMA. The ML tree is presented in Fig 4.1. In the ML tree sixty isolates grouped within sub-lineage O/ME-SA/Ind2001e indicating its extended dominance since its emergence during the year 2016. This sub-lineage gradually displaced O/ME-SA/Ind2001d from field as none of the isolates collected during 2018-19 clustered within Ind2001d sub-lineage. Twenty two isolates clustered distinctly in unnamed group but shared ancestry with Ind2001 lineage. The clustering is maintained in NJ and UPGMA trees. The isolates were collected during February to December, 2018 from the states of Uttarakhand, Haryana, Karnataka, Kerela and Tamilnadu. The earliest isolate in this group was from the state of Uttarakhand during February 2018. The new group of lineage Ind2001 is highly homogenous with a mean distance of 0.01 among them and had a mean distance of 0.046 from Ind2001e sub-lineage. Similar to last year, **the isolates of Ind2001e collected during 2018-19 are highly homogeneous** with only 0.017 mean nucleotide distance demonstrating an epidemiological link among most of these incidences. Free movement of infected animals/contaminated objects/personnel continued to be the major mode of virus transfer. The Ind2001e isolates and new group isolates collected during 2018 differed from currently used vaccine strain INDR2/1975 by 8.1% and 8.6%, respectively at nucleotide level at 1D genomic region nucleotide sequence. Surprisingly, the isolates collected from the states of Uttarakhand, Haryana, Karnataka and Tamilnadu during the same time point clustered in Ind2001e sub-lineage and new group as well indicating **multiple independent incursion/evolution of virus in the states.**

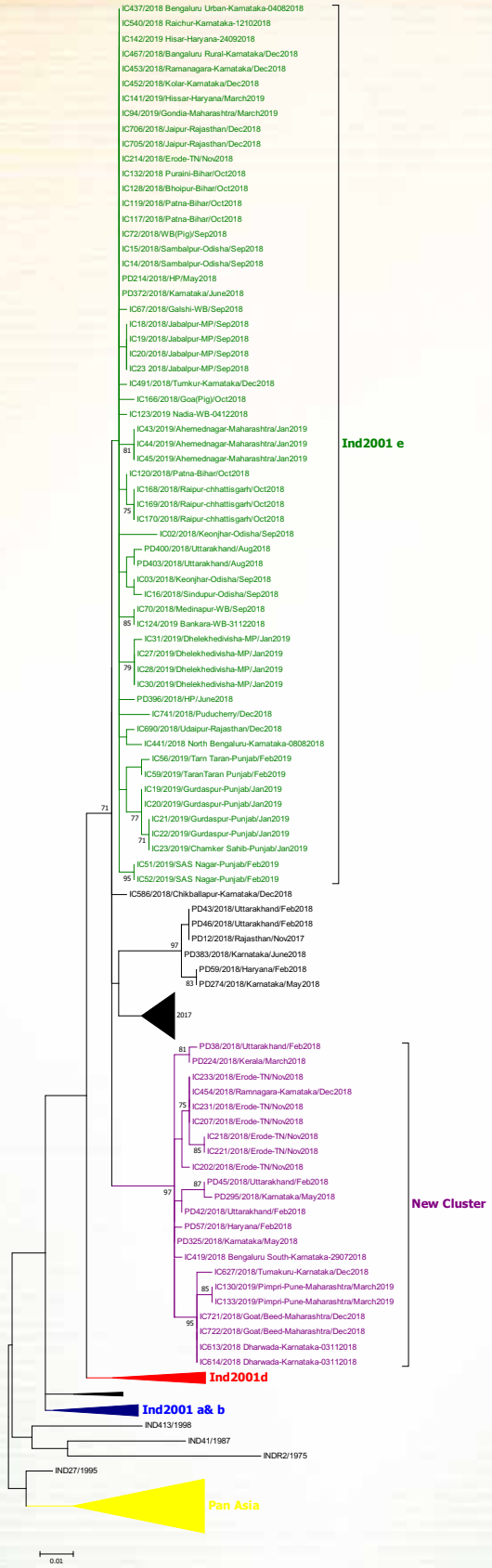


Fig. 4.1 Maximum Likelihood phylogenetic tree at VP1 coding region of Indian serotype O FMD virus isolates during 2018-19. The analysis shows dominance O/ME-SA/Ind2001e sub-lineage in India during the period.

2. FMDV Serotype A

Among all serotypes prevalent in India, serotype A virus population is genetically and antigenically most heterogeneous in nature. VP1(1D) coding region based molecular phylogeny has established circulation of four genotypes {showing more than 15% nucleotide (nt) divergence among them at 1D region} of serotype A so far in India. Since 2001, genotype 18 has been exclusively responsible for all the field outbreaks and has outcompeted all other 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 59th position of VP3 (VP3^{59}-deletion group) and dominated the field outbreak scenario in 2002-03. Ever since then sporadic outbreaks due to this lineage has been identified. This single aa deletion is at an antigenically critical position in structural protein VP3, which is considered to be a major evolutionary jump probably due to immune selection. Recently, it has been observed that the deletion group is on the verge of overthrowing the nondeletion variants and establishing itself as the only prevalent genetic cluster. The isolates of 2015-16 clustered within genotype 18 in the maximum likelihood tree, and grouped only in the clade 18c of the VP3^{59}-deletion lineage (Fig. 4.2). Clade 18c which was first reported from Southern peninsular India during 2007 seems to have disseminated to Central, Eastern, Western and Northern parts of India after 2009. Interestingly, not a single field outbreak virus without the VP3-59 deletion could be identified during 2015-16 in support of the anticipated exclusive dominance of the VP3^{59}deletion group. For the last three years, no incidence of FMDV serotype A is recorded in the country.

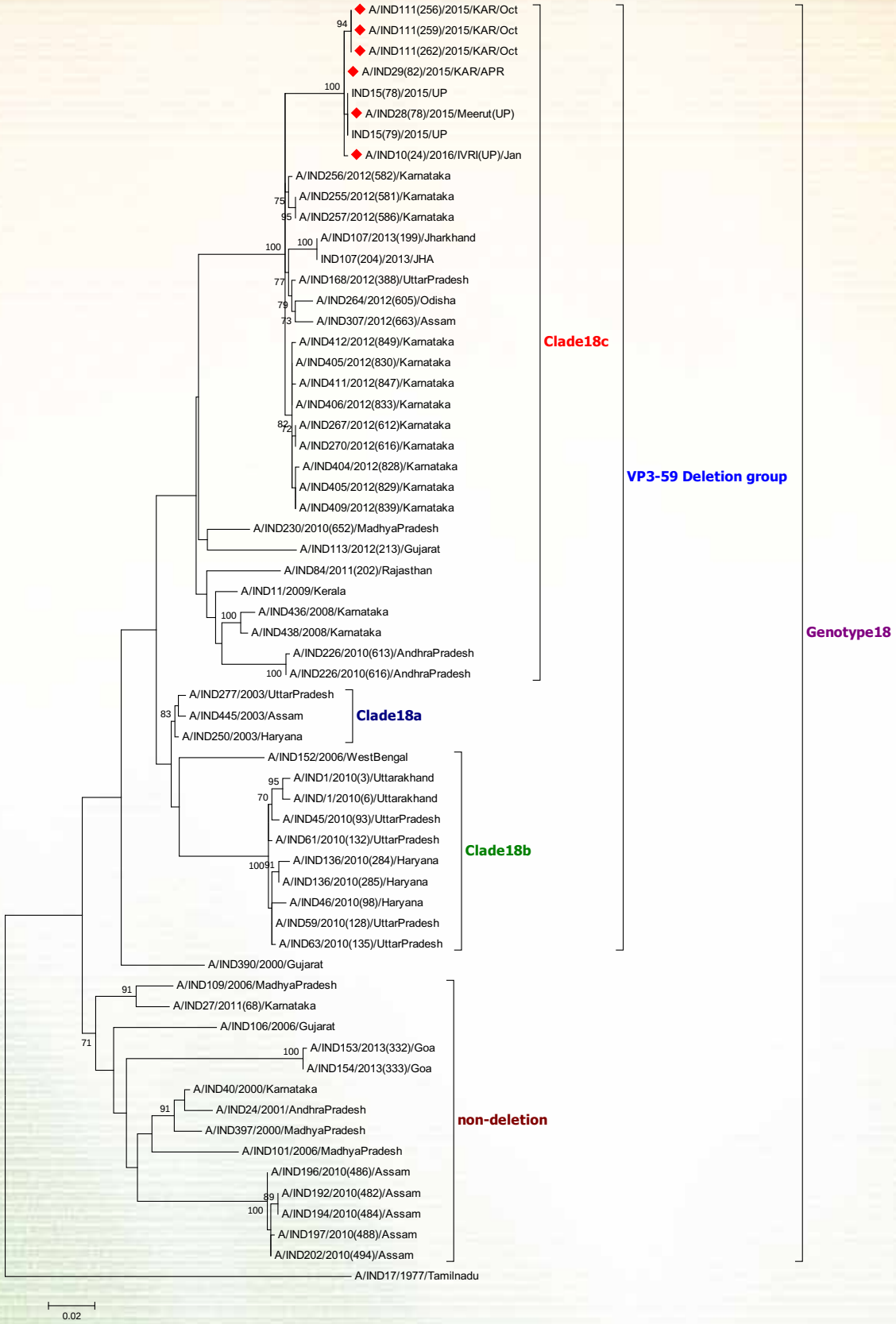


Fig 4.2: Maximum likelihood tree depicting phylogenetic relationship of serotype A isolates collected during 2015-16. All the isolates were found belong to clade 18c of VP3[59] deletion group.

3. FMDV Serotype Asia1

Previous studies on 1D/VP1 gene based phylogeny demarcated Indian serotype Asia1 field isolates in to three major lineages namely B, C and D. Lineage B which include currently used serotype Asia1 vaccine strain, IND63/1972, was last recorded in the year 2000. The isolates of lineage D emerged late in 2001 and dominated the period between 2002 and 2004. The lineage C dominated the Asia1 field outbreaks between 1998 and 2002, although disappeared between year 2001 and 2004, and re-emerged as the predominating lineage from 2005 onwards.

The serotype Asia1 isolates collected during January 2019 from the state of Assam clustered within sub-lineage CII and the isolates were found to cluster closely with the isolates from Nagaland in December'15 (Fig 4.3). During 2016-17, no incidence of FMDV serotype Asia1 was recorded in the country. Three incidences were recorded during 2017-18 in the states of Kerala and Rajasthan, but the samples were not forwarded to central laboratory, Mukteswar for strain characterization.

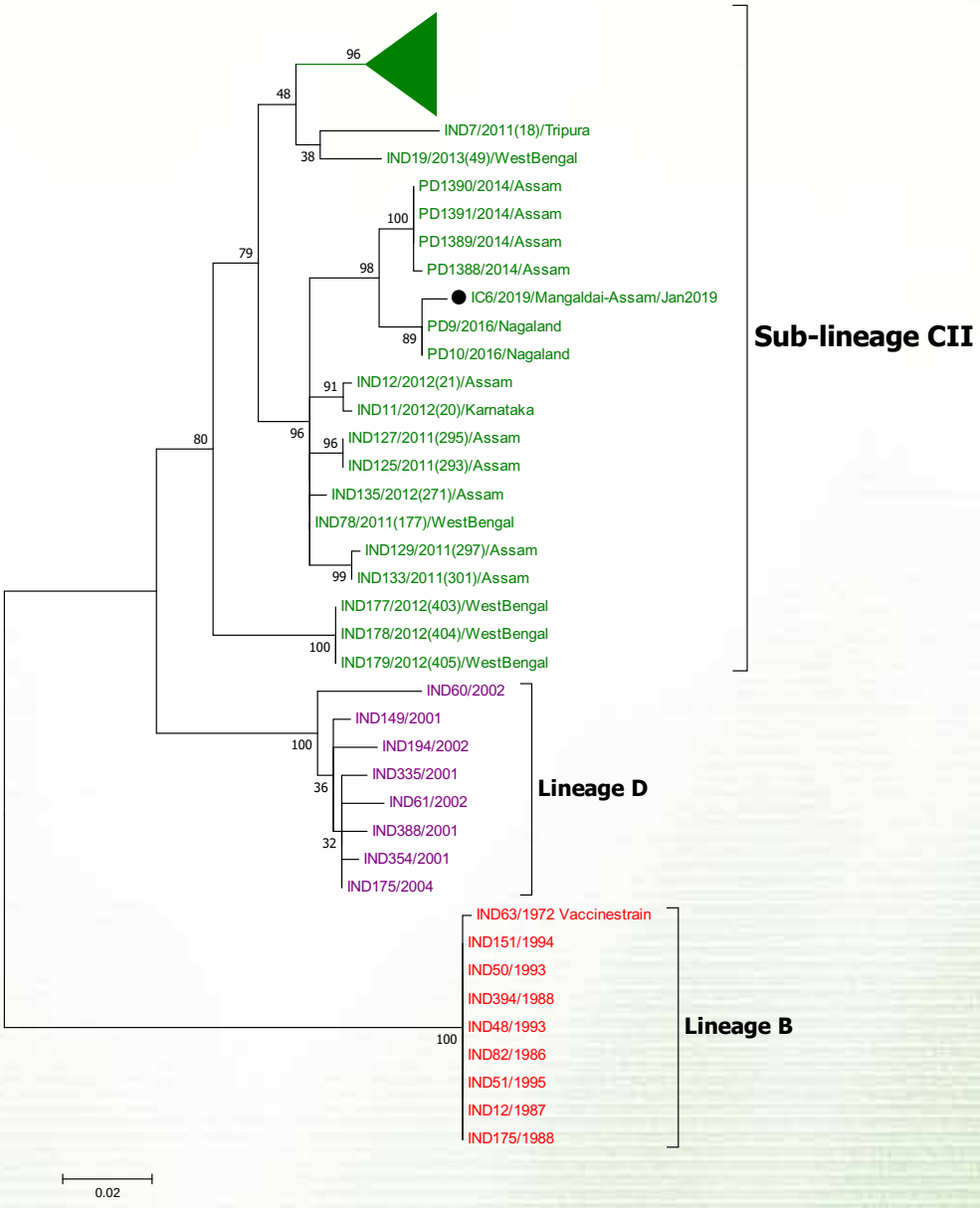


Fig. 4.3: Maximum likelihood phylogenetic tree at VP1 coding region of FMD virus isolates of serotype Asia1 during 2015-16. Lineage C is in circulation in the country since 2005.

Vaccine matching of FMD virus field isolates

5

1 FMDV serotype O

The antigenic relationships of serotype O field isolates to the currently used vaccine strain INDR2/1975 is shown in Fig.5.1. The test results were interpreted as per criteria set by Rweyemamu, (1984). During 2018-19, a total of 37 virus isolates were subjected to vaccine matching exercise using bovine vaccinate serum. The isolates were sampled from different states and different time point. From the result, it can be seen that only a single isolate had a low r1 -value and two isolates had r1 -value between 0.2-0.3. Rest of the 34 isolates had an r1 -value of >0.3. In total, 93.5% of the isolates showed antigenic homology with currently used serotype O vaccine strain INDR2/1975, which indicates optimal antigenic coverage by the in-use vaccine strain. The strain INDR2/1975 is suitable for use in vaccine formulation. There is no emergence of antigenic variants in case of serotype O during 2018-19, irrespective of numerous FMD outbreaks encountered during the period.

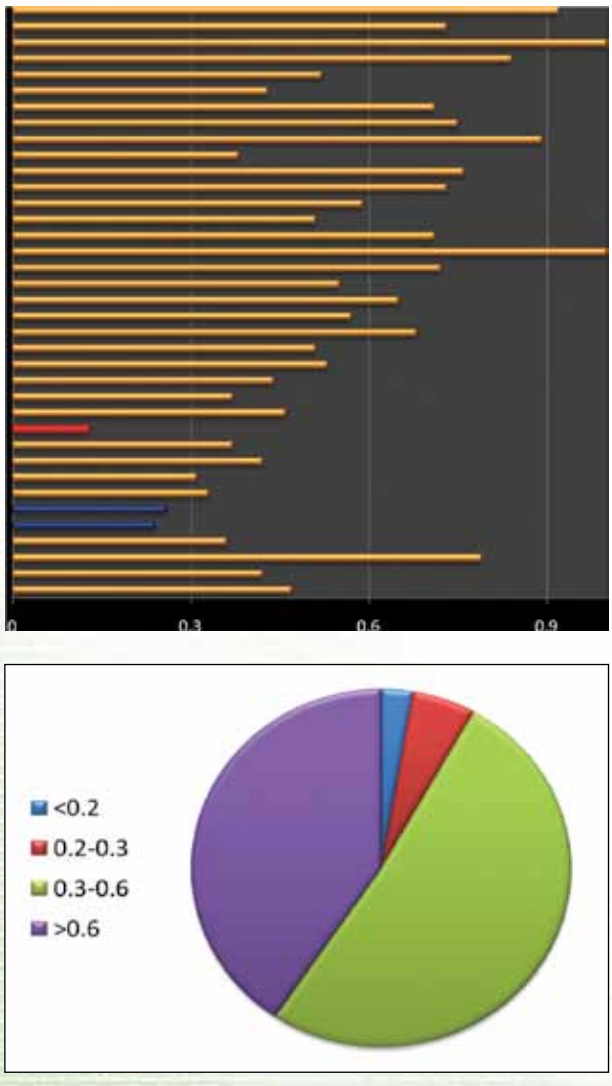


Fig 5.1: Antigenic coverage of current field isolates by serotype O vaccine strain IND R2/1975.

2 FMDV serotypes A and Asia1

The field situation suggested emergence of antigenically divergent strains in serotype A, while majority of isolates in Asia 1 were found to be antigenically related to the in-use vaccine strain, IND63/1972. With the recent emergence of antigenically divergent VP3[59]-deletion group in serotype A, again a quest for back up candidate vaccine strains was initiated and the best strain showing broader antigenic relatedness (A IND 27/2011) out of the eight shortlisted strains was selected for further studies with respect to the vaccine worth attributes. The new serotype A candidate strain A IND 27/2011 will replace the existing vaccine strain A IND 40/2000. The studies on vaccine attributes of strain A IND 27/2011 have been completed. Besides, attempts were also made to maintain a panel of most suitable candidate vaccine strains for each serotype to meet any exigency or to cater to demand based vaccination if need arises. Complete nucleotide sequence of all the short listed strains was generated as a part of the study.

6 Research for Development

Evaluation of thermo-tolerant FMDV serotype O vaccine candidate

1. Introduction

A major problem that limits the efficacy of the currently available conventional inactivated FMD vaccine is that the virus is sensitive to high environmental temperature leading to a loss of immunogenicity and therefore, application of FMD vaccine in the field requires expensive cold chain management. Furthermore, although the majority of FMD outbreaks are due to FMD virus serotype O, the level of protective immunity attained with the oil-adjuvant vaccine is about 70%-80% for serotype O, this could be due to fact that serotype O viruses are more thermal-labile compared to other FMDV serotypes. This is where a thermo-tolerant vaccine would be critical. ICAR-Directorate of FMD, Mukteswar, through reverse genetics approach had earlier developed a thermo-tolerant mutant virus from currently used FMD serotype O vaccine strain (IND R2/1975). This mutant virus needed further studies to find out it's suitability as vaccine before replacing the existing vaccine strain which was taken up at ICAR-IVRI, Bengaluru with the following objectives,

2. Objectives

i. To study various vaccine attributes of thermo-tolerant mutant of FMD virus serotype O IND R2/1975.

ii. To evaluate immune response and potency of thermo-tolerant type O vaccine in natural host through animal challenge experiments.

3. Principal Findings

i. Thermo-tolerant FMD virus serotype O candidate vaccine strain was evaluated for potency in cattle at an antigenic mass of 10mg per dose.

ii. In the short term immunity study, vaccinated animals were challenged with parent serotype O virus on 28th day post-vaccination which resulted in 83.33% protection in thermo-tolerant vaccine group compared to 100% protection in parent O vaccine group.

iii. In the long term immunity study with booster, high level of antibody titre was observed even after 6 months of booster. The vaccinated animals were challenged with parent serotype O virus on completion of 6 months after booster which resulted in 87.5% protection in thermo-tolerant vaccine group compared to 100% protection in parent O vaccine group.

iv. In the long term immunity study without booster, protective levels of antibody titre was observed even after 6 months post-vaccination. The vaccinated animals were challenged with parent O virus on completion of 6 months of vaccination which resulted in 100% protection in thermo-tolerant vaccine group.

v. In order to study stability of the vaccine, animals were vaccinated after 8 months of storage of the vaccine in the refrigerator. Antibody level had declined compared to the vaccination trial with fresh vaccine, although it was more in thermo-tolerant vaccine as compared to parent virus vaccine. The vaccinated animals were challenged with parent O virus on 28th day post-vaccination which resulted in 75.0% protection in thermo-tolerant vaccine group compared to 100% protection in parent O vaccine group.

4. Conclusions

i. Introduction of mutation in the genome of currently used FMDV serotype O vaccine strain (O R2/1975) enhances the thermo-tolerance of the virus.

ii. The vaccine virus with increased thermo-tolerance retains all the vaccine worth attributes viz., adaptability to suspension BHK-21 cells, high titre, genetic and antigenic stability, thermal & BEI inactivation properties and antigenic spectrum.

iii. The vaccine virus with increased thermo-tolerance is a better immunogen compared to its parent virus in terms of antibody response with and without booster vaccination in animals. The booster regimen elicits robust antibody response that is maintained at elevated levels compared to single vaccination.

iv. The immunization of animals with thermo-tolerant virus vaccine confers protection against virulent challenge.

v. The study indicates the superiority of the thermo-tolerant virus as vaccine strain over parent virus that can replace the existing in-use serotype O vaccine strain.

vi. The study also substantiate the need of booster FMD-vaccination (at least to the first-time vaccinated animals), in order to have a robust long-lasting immune response against FMD virus.

5. Future studies

i. Dose response study to identify the minimum antigenic mass required for protection in animals at different time intervals.

ii. Field trials are required to be conducted to validate the efficacy of the vaccine under field conditions.

iii. Thermo-tolerant virus strains need to be developed and evaluated for other serotypes (A and Asia-1).

7 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 91 serotype O virus isolates were added to the repository during the reported period (Table 7.1). At present the National FMD virus Repository holds a total of 2278 isolates (O-1574, A-323, C-15 and Asia 1-366).

Table 7.1: Year-wise details of the virus isolates added to National FMD Virus Repository during last five years.

Isolates revived	O	A	Asia1	Total
2013-14	61	10	2	73
2014-15	12	-	4	16
2015-16	55	11	2	68
2016-17	53	4	-	57
2017-18	121	-	-	121
2018-19	91	-	-	91

National FMD Sero-Surveillance

8

During the year, a total of 51,485 bovine serum samples collected at random from various parts of the country were tested in r3AB3 NSP-ELISA for assessing NSP-antibody (NSP-Ab) response, which is an underlying indicator of FMD virus exposure regardless of vaccination status. The test revealed overall seropositivity (DIVA positive) in ~ 20% samples/animals (Table 8.1). Till now, a total of 4, 96,101 random serum samples from bovine have been analyzed by DIVA.

Table 8.1. Summary of DIVA reactivity in bovine during 2018-19

Sl. No.	State	Total serum samples tested	Total positive	%3AB3 reactors
Southern Region				
1	Telangana	1695	17	1.00
2	Tamil Nadu	6400	1919	29.98
3	Andhra Pradesh	2600	43	1.654
4	Karnataka	5979	1375	23.00
5	Kerala	1500	79	4.94
Central Region				
6	Madhya Pradesh	9280	1504	16.2
Western Region				
7	Maharashtra	2976	110	3.7
8	Gujarat	5200	2164	42.0
Eastern Region				
9	West Bengal	1994	1015	51.79
10	Odisha	1014	463	44.86
Northern Region				
11	Haryana	1700	138	8.12
12	Uttar Pradesh	4315	405	9.4
13	Himachal Pradesh	346	69	19.9
14	Jammu and Kashmir	1800	442	24.55
15	Punjab	3788	386	10.19
North Eastern Region				
16	Assam	730	149	20.41
17	Meghalaya	86	26	30.23
UT				
18	Andaman & Nicobar	82	6	11.12
Total		**51485**	**10310**	**20.02**

9 Seromonitoring of FMD Control Programme (FMDCP)

A bi-annual vaccination based FMD Control Programme (FMDCP) was initiated by the Government of India since 2004, initially covering 54 districts (Phase I) in the country. This involves 6 monthly FMD vaccinations, with a trivalent O, A and Asia1 vaccine, of all cattle and buffaloes for protection against FMD. Serum samples before vaccination and 21 to 30 days post vaccination are collected by the respective state AH departments and tested by ICAR-DFMD for estimation of level of serotype specific antibodies. Under a MoU between DAHD&F and ICAR, the institute (ICAR-DFMD) has been providing all the required laboratory and scientific support to the FMD control programme since 2003-04. The institute undertakes the huge task of seromonitoring of the FMDCP running in the entire country, and analyze the data in relation to the herd immunity, level of seroconversion, number of occurrence of FMD and DIVA status. Due to initial success data generated by this institute, additional 167 districts (another 80-90 million cattle and buffalo) were included under the programme in 2010-11 (Phase II), and 110 districts were included since 2013-14 (Phase III), and 38 districts in 2015-16 (Phase IV). The states of West Bengal, Chhattisgarh, Himachal Pradesh, Madhya Pradesh and Uttarakhand are under FMDCP since 2017 (Phase V). In phase VI, rest of the states were covered. Currently, this programme covers entire country.

The Liquid Phase Blocking ELISA for monitoring of herd immunity following each round of vaccination was used till the year 2015. Subsequently, a solid phase competitive ELISA (SPCE) in four dilution format was developed for the sero-monitoring activity under FMDCP. The SPCE is suitable for mass serology and is routinely used in World Reference Laboratory (WRL) on FMD, Pirbright, UK. Further, the specificity of the SPCE was reported by many research publications to be considerably higher than that of the liquid phase blocking ELISA and almost equivalent to that of the virus neutralisation test. It is easier to use, more robust and specific, and therefore offers an improvement for FMD virus specific antibody detection. Therefore the SPCE developed at ICAR-DFMD was applied for determination anti-FMDV antibody status in the FMDCP areas.

During 2018-19, using SPCE, a total of 2,31,983 serum samples (pre-vac: 1,15,744 and post vac: 1,16,239) were tested under FMD-CP at National FMD-CP Sero-monitoring Laboratory. Besides, 4356 serum samples received from various Breeding Bull station and random samples were also tested.

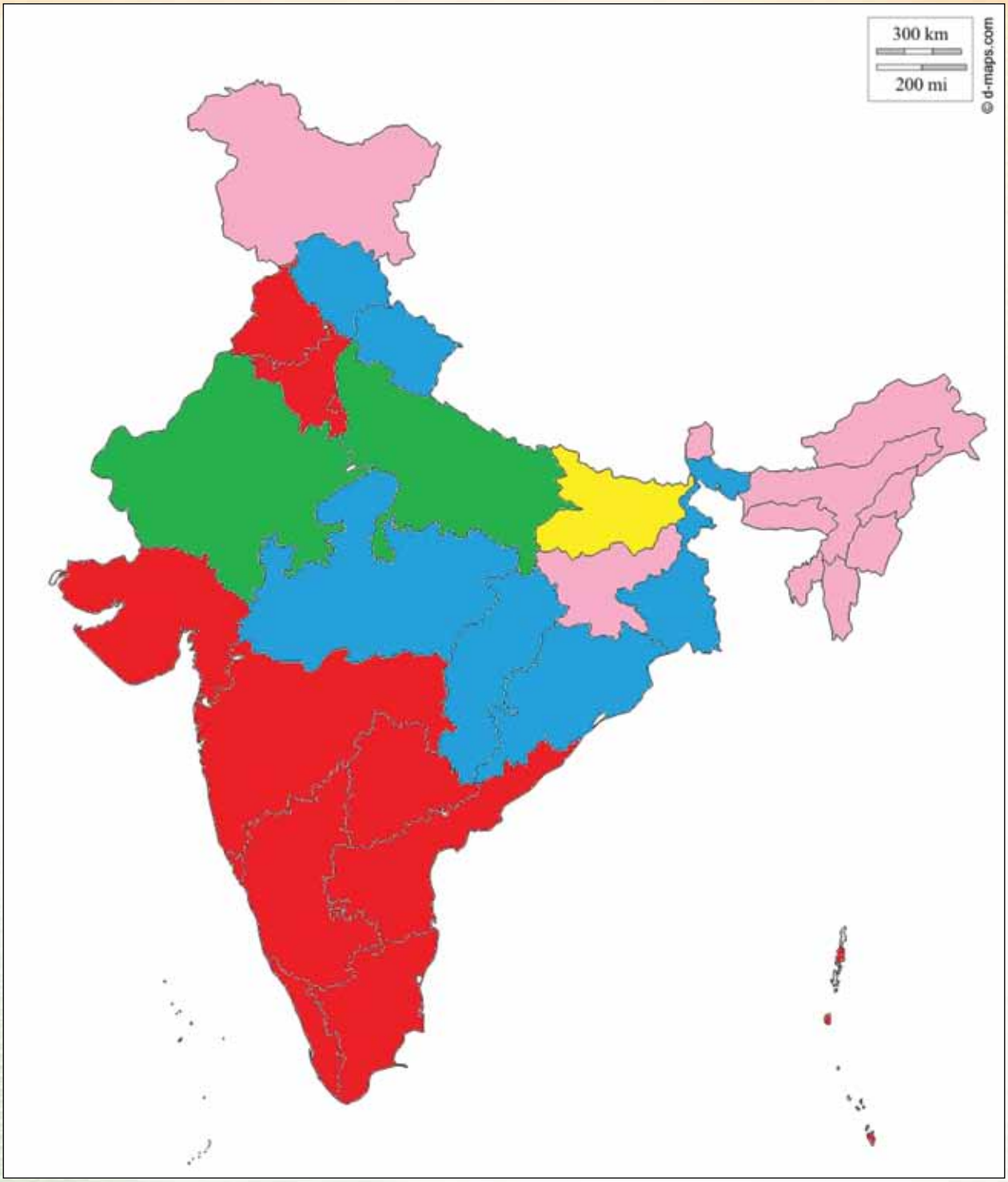


Fig. 9.1: Regions covered fully since 2011 marked red. Regions covered fully since 2014 marked Green. Regions covered fully since 2016 marked Yellow. Regions covered fully since 2017 marked Blue. Regions covered fully since 2018 marked Pink.

State-wise details are mentioned below:

State of Tamil Nadu

The state of Tamil Nadu has 33 districts in which the district Kanyakumari alone was covered under FMDCP in Phase I in 2004-05 and later rest of the districts were included in Phase II since 2011.

- A total of 85,733 pre-vac and 85,281 post-vac samples have been tested till now.
- The pre-vac antibody level (herd immunity) has dropped from >80% during 2014-15 to 53-70% during 2016-17. Further drop was observed during 2018 to 40-53%
- Decline in antibody level in post-vac serum also observed subsequent to round 9.
- Overall at the end of latest round in 2018, 69-77% of the animals had protective antibody titre.

Table 9.1a: *Sero-conversion and Herd immunity in Tamil Nadu*

Tamil Nadu (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 $\log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2007)	100	100	28(28)	51(51)	29(29)	57(57)	24(24)	54(54)
2(2008)	100	100	23(23.0)	63(63.0)	24(24.0)	40(40.0)	18(18.0)	61(61.0)
3 (2008) & 4 (2009)	180	330	59(32.7)	246(74.5)	61(33.8)	201(60.9)	45(25.0)	216(65.4)
6(2010)	160	130	30(18.7)	99(76.1)	31(23.8)	109(83.8)	28(21.5)	103(79.2)
7(2010)	300	300	35(11.7)	210(70)	34(11.3)	231(77)	36(12)	226(75.3)
8 (2011)	100	100	34(34)	74(74)	40(40)	60(60)	25(25)	78(78)

Tamil Nadu (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 $\log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1/9(2011)	5440	5440	1860(34.2)	3417(62.8)	1351(24.8)	2561(47.1)	115(20.5)	2209(40.6)
2/10(2012)	5040	5240	1383(27.4)	3504(66.9)	684(13.6)	2433(46.4)	245(04.9)	979(18.7)
3/11(2012)	4600	4600	789(17.2)	2788(60.6)	396(08.6)	1801(39.2)	1030(22.4)	3361(73.1)
4/12(2013)	5801	5843	2570(44.3)	4547(77.8)	3296(56.8)	4826(82.6)	3643(62.8)	5066(86.7)
5/13(2013)	7199	6397	4089 (56.8)	5598(87.5)	4434(61.6)	5816(91)	4501(62.5)	5788(90.5)
6/14(2014)	6400	6400	5041 (79.0)	6180(96.6)	4230(66.1)	6028(94.2)	5002(78.2)	6240(97.5)
7/15(2014)	6400	6400	5332 (83.3)	6180 (96.6)	5016 (78.4)	6028 (94.2)	5572 (87.1)	6240 (97.5)
8/16(2015)	6400	6400	5480 (85.6)	6287 (98.2)	5348 (83.6)	6259 (97.8)	5845 (91.3)	6322 (98.8)
9/17(2015)	6400	6400	5517 (86.2)	6224 (97.3)	5230 (81.7)	6126 (95.7)	5547 (86.7)	6282 (98.2)
11/18(2016)	6156	6199	3967(64.4)	5172(83.4)	3472(56.4)	4891(78.9)	4318(70.1)	5364(86.5)
12/19(2017)	6400	6400	3798(59.3)	4930(77.0)	3366(52.5)	4770(74.5)	3907(61.0)	4964(77.6)
13/20(2017)	6000	6000	3731(62.2)	5081(84.7)	3169(52.8)	4608(76.8)	3567(59.5)	4808(80.1)
14/21(2018)	6357	6302	3401(53.5)	4940(78.4)	2907(45.7)	4427(70.2)	3324(52.3)	4713(74.8)
15/22(2018)	6200	6200	2934(47.3)	4800(77.4)	2496(40.2)	4290(69.2)	3204(51.7)	4584(73.9)

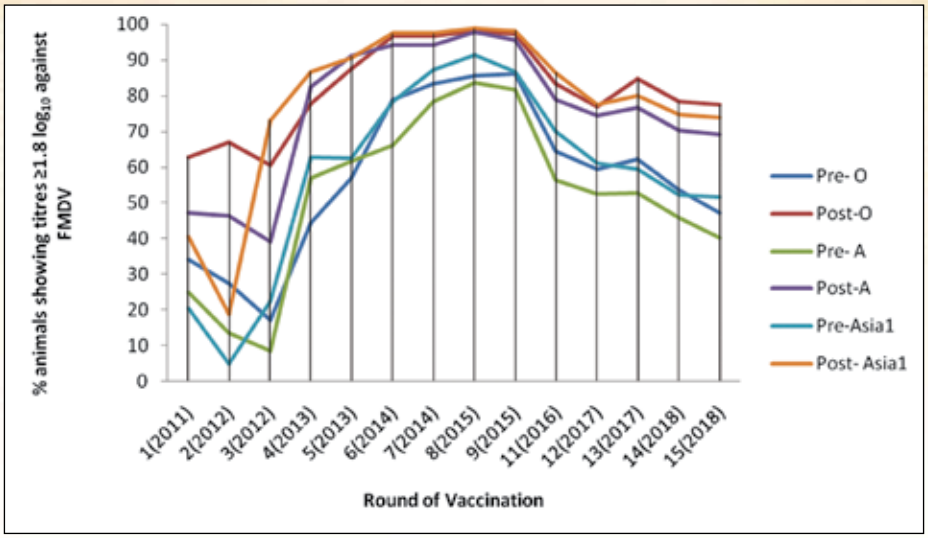


Fig. 9.1b: *Percent animals showing protective antibody titre against different serotypes*

State of Karnataka

Entire state of Karnataka was included under FMDCP in Phase II since 2011.

- A total of 76,142 pre-vac and 74,386 post-vac samples have been tested till now.
- Drop in pre and post vac titre was observed after round 12 that was carried out in the year 2017.
- The pre-vac antibody titre has dropped from 74-88% to 41-47% at the end of round 14. Similarly post-vac titre has also dropped from 84-90% to 56-67%
- Further only single round of vaccination was carried out during the year 2018 which may affected the herd immunity and seroconversion

Table 9.2a: ***Seroconversion and Herd immunity in Karnataka***

Round of vaccination	Number of serum samples		Number and Percent animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2011)	4587	4266	1817(40.0)	2383(56.0)	687(15.0)	1722(40.0)	426(9.0)	1049(24.5)
2(2012)	5401	4632	2718(50.0)	3101(67.0)	1471(27.0)	2161(47.0)	1577(39.0)	2354(51.0)
3(2012)	3864	3075	2118(54.8)	1855(60.3)	1129(29.2)	1289(41.8)	2376(61.5)	2158(70.2)
4(2013)	5053	5225	2439(48.3)	3245(62.1)	3977(78.7)	4493(86.0)	3834(76.0)	4294(82.2)
5(2013)	5916	5853	1954(33.0)	3470(59.0)	3047(52.0)	3957(68.0)	3795(64.0)	4734(81.0)
6(2014)	5945	5985	3651(61.0)	5434(86.0)	3689(62.0)	5182(87.0)	4446(75.0)	5538(92.5)
7(2014)	5930	5930	4934(83.0)	5741(97.0)	5211(88.0)	5567(94.0)	5543(93.0)	5813(98.0)
8(2015)	5974	5994	5227(87.5)	5723(95.5)	5073(84.9)	5794(96.7)	5447(91.2)	5823(97.1)
9(2015)	5947	5958	4369(73.5)	5234(87.8)	3886(65.3)	5122(86.0)	4460(74.9)	5361(89.9)
10(2016)	4264	4360	3009(70.6)	3613(82.9)	2518(59.1)	3306(75.8)	3176(74.5)	3654(83.8)
11(2016)	5427	5161	3685(67.9)	4234(82.0)	3419(63.0)	4023(78.0)	3897(71.8)	4163(80.7)
12(2017)	6000	6000	4505(75.0)	5247(88.0)	5247(88.0)	5386(90.0)	4642(74.0)	5021(84.0)
13(2017)	5947	5950	3124(52.5)	4150(69.7)	2723(45.8)	3641(61.2)	3063(51.0)	3922(65.9)
14(2018)	5887	5997	2835(47.4)	3885(64.8)	2501(41.8)	3365(56.1)	2646(44.2)	3379(56.3)

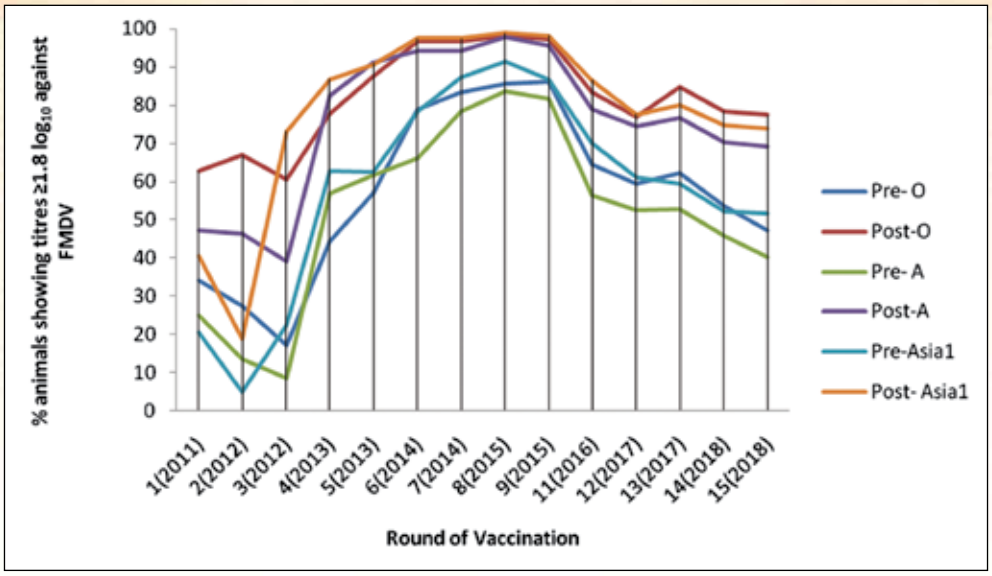


Fig. 9.2b: *Percent animals showing protective antibody titre against different serotypes.*

State of Kerala

The state of Kerala has 14 districts in which three districts namely, Trivandrum, Kollam and Pathanamthitta were covered under FMDCP in Phase I and later, eleven districts were included in Phase II since 2011.

- A total of 24,964 pre-vac and 23,410 post-vac samples have been tested till now.
- The pre-vac antibody titre (herd immunity) has dropped to 41-60% before 12th round of vaccination from >75% earlier.
- The post-vac antibody titre after 13th round is good at >83% against serotype O and Asia1

Table 9.3a: ***Seroconversion and Herd immunity in Kerala***

Kerala (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2006) & 2 (2007) & 4(2008)	483	496	158(32.7)	255(51.4)	140(29.0)	236(47.5)	165(34.2)	280(56.4)
5(2008)	290	290	67(23.1)	197(67.9)	52(17.9)	171(58.9)	61(21.0)	211(72.7)
6(2009)	70	70	49 (20.4)	185(77.1)	41(17.1)	169(70.4)	38(15.8)	171(71.3)
7(2009)	300	300	48 (16.0)	208(69.3)	43 (14.3)	213 (71	52 (17.3)	210(70.0)
8 & 9 (2010)	600	600	226(37.6)	395(65.8)	265(44.2)	341(56.8)	260(43.3)	397(66.2)
10(2011)	400	100	160(40)	59(59)	145(36.3)	66(66)	150(37.5)	53(53)
11(2011)	352	315	122(19)	122(19)	122(19)	115(17.2)	96(14.4)	88(13.2)

Kerala (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2/12(2012)	676	180	84(12.4)	65(36.1)	105(15.5)	65(36.1)	65(9.6)	61(34.0)
3/13(2012)	1631	1474	199(12.2)	525(35.6)	178(10.9)	484(32.8)	135(8.3)	376(25.5)
4/14(2013)	2378	2109	308(13.0)	526(25.0)	362(15.2)	633(30.0)	404(17.0)	735(35.0)
5/15(2013)	2043	1941	400(20.0)	991(51.1)	505(24.7)	1135(58.5)	922(45.1)	1364(70.3)
6/16(2014)	2789	2738	1498(53.7)	2479(90.5)	1425(51.1)	2164(79.0)	1709(61.3)	2415(88.2)
7/17(2014)	2791	2678	2137(76.6)	2173(81.1)	1786(64.0)	2462(92.0)	2184(78.3)	2600(97.1)
8/18(2015)	2800	2800	2303 (82.3)	2575 (92.0)	2145 (76.6)	2441(87.2)	2467 (88.1)	2686(95.9)
11/19(2016)	2361	2321	1581(67.0)	1920(82.7)	1355(57.4)	1847(79.6)	1427(60.4)	1847(79.6)
12/20 (2017)	2200	2198	1134(51.5)	1834(83.4)	1201(54.6)	1827(83.1)	1353(61.5)	1905(86.7)
13/21(2018)	2800	2800	1653(59.0)	2347(83.8)	1149(41.0)	1930(68.9)	1679(59.9)	2353(84.0)

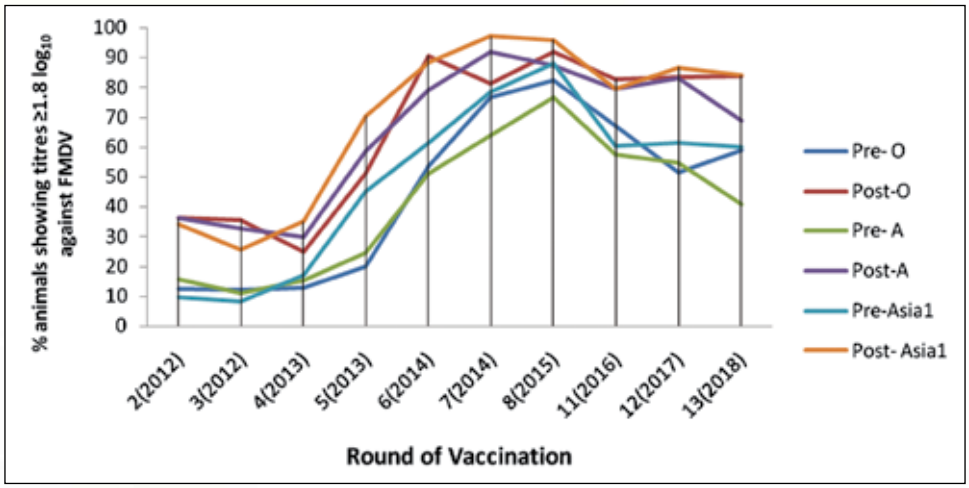


Fig. 9.3b: *Percent animals showing protective antibody titre against different serotypes.*

State of Andhra Pradesh

Two districts of Andhra Pradesh (Ananthapur and Chitoor) were covered under FMDCP in Phase I since the year 2004 and rest of the districts were included in Phase II, since the year 2011.

- A total of 23,080 pre-vac and post-vac samples from united AP, 23,449 pre-vac and 23,450 post-vac samples from new AP have been tested till now.
- The pre-vac titre is 31-47% at the end of 15th round which is low and needs to be improved
- The post-vac titre is good at 66-76% at the end of 15th round which needs to increased to >80%
- No incidence of FMD since 2014-15 is a good sign for the control programme. But the situation may change if DIVA reactivity/positivity is not controlled.

Table 9.4a: *Seroconversion and Herd immunity in Andhra Pradesh*

AndhraPradesh/Telangana (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 $\log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2006)	800	800	83 (10.3)	340 (42.5)	43 (5.3)	244 (30.5)	92 (11.5)	340 (42.5)
2(2006)	800	800	N.A.	434 (54.2)	N.A.	498 (62.3)	N.A.	438 (54.7)
3(2007)	800	800	210 (26.2)	286 (35.7)	395 (49.3)	532 (66.5)	306 38.2)	422 (52.7)
4(2007)	800	800	281 (35.1)	374 (46.8)	465 (58.1)	617 (77.1)	329 41.1)	518 (64.8)
5(2008)	800	800	247 (30.8)	440 (55)	466 (58.2)	574 (71.8)	343(42.8)	450 (56.3)
6(2008)	800	800	275 (34.3)	490 (61.3)	554 (69.2)	690 (86.3)	446 55.7)	634 (79.3)
7(2009)	800	800	274 (34.0)	483 (60.3)	349 (44.0)	540 (67.5)	391(48.8)	518 (64.7)
8(2009)	800	800	356 (44.5)	594 (74.0)	415 (51.8)	624 (78.0)	333(41.6)	527 (65.8)
9(2010)	800	800	422 (52.8)	673(84.1)	329 (41.1)	534 (66.8)	287(35.9)	534 (66.8)
10(2010)	800	800	502(62.7)	635(79.3)	368(46)	575(71.8)	411(51.3)	602(75.2)
11(2011)	800	800	398(49.75)	617(77.1)	356(44.5)	600(75)	333(41.6)	568(71.5)

AndhraPradesh/Telangana (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 $\log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1/12(2011)	3600	3600	1043(29.0)	2396(66.5)	648(18.0)	2030(56.4)	419(13.1)	1709(47.5)
2/13(2012)	3480	3480	1435(41.2)	2381(68.4)	1026(29.5)	2054(59.0)	595(17.1)	1499(43.1)
3/14(2012)	3600	3600	1392(38.6)	2498(69.3)	750(20.8)	1661(46.1)	393(10.9)	1162(32.2)
4/15(2013)	3600	3600	1364(38.0)	2354(65.4)	1356(37.7)	2821(78.4)	1663(46.2)	2788(77.4)
5/16(2013)	3600	3600	1546(42.9)	2478(68.6)	2292(63.6)	3153(87.5)	2574(71.5)	3239(89.9)
Andhra Pradesh								
6/17(2014)	1800	1800	1053(58.5)	1359(75.5)	850(47.2)	1211(67.2)	1023(56.8)	1269(70.5)
7/18(2014)	1800	1800	1224(68.0)	1453(80.7)	825(45.8)	1302(72.3)	1189(66.0)	1492(82.8)
8/19(2015)	1800	1800	1303(72.3)	1563(86.8)	997(55.3)	1481(82.2)	1242(69.0)	1567(87.1)
9/20(2015)	2595	2598	1372(52.9)	1869(71.9)	961(37.0)	1528(58.8)	1243(47.9)	1861(71.8)
10/21(2016)	2598	2596	1609(61.9)	1965(75.7)	1303(50.2)	1735(66.8)	1427(54.9)	1793(69.1)
11/22(2016)	2480	2480	1274(51.4)	1581(63.8)	887(35.8)	1339(54.0)	1096(44.2)	1561(63.0)
12/23(2017)	2576	2576	1260(48.9)	1553(60.3)	780(30.3)	1158(45.0)	1182(45.9)	1567(60.8)
13/24(2017)	2600	2600	925(35.6)	1452(55.8)	799(30.7)	1341(51.6)	1040(40.0)	1560(60.0)
14/25(2018)	2600	2600	928(35.7)	1521(58.5)	732(28.2)	1309(50.3)	1006(38.7)	1474(56.6)
15/26(2018)	2600	2600	1171(45.0)	1968(75.7)	806(31.0)	1718(66.0)	1209(46.5)	1882(72.4)

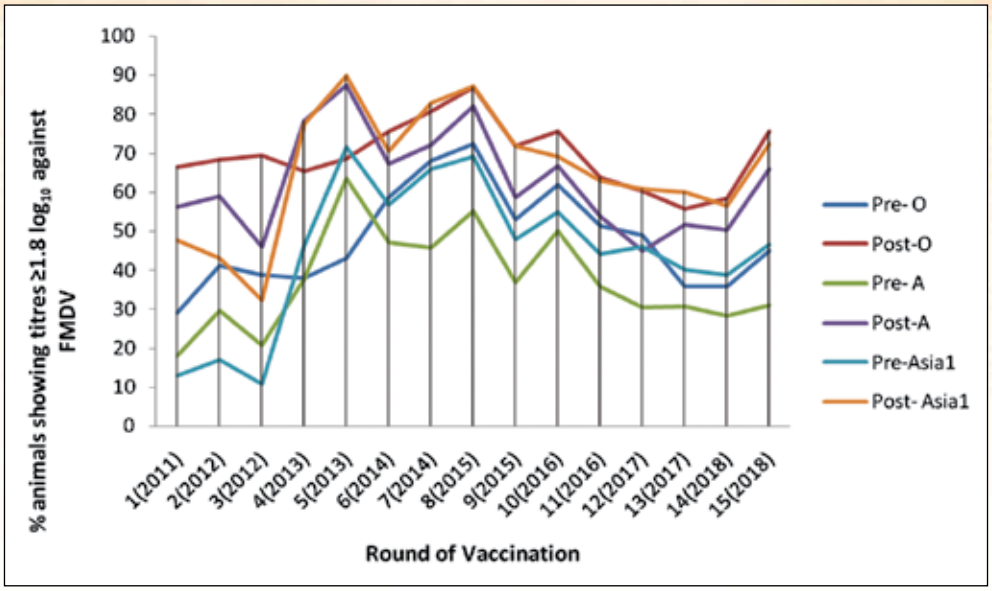


Fig. 9.4b: *Percent animals showing protective antibody titre against different serotypes.*

State of Telangana

Two districts of Telangana (Medak and Rangareddy) were covered under FMDCP in Phase I since the year 2004, and rest of the districts were included in Phase II, since the year 2011

- A total of 21,395 pre-vac and 21,385 post-vac samples from united AP, 14,229 pre-vac and 14,153 post-vac samples from Telangana state have been tested till now.
- The pre-vac titre after 14th round is 38-53% and drop was observed compared to earlier round
- The post-vac titre after 14th round is 63-78% that is slightly high compared to earlier round

Table 9.5a: ***Seroconversion and Herd immunity in Telangana***

AndhraPradesh/Telangana (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2006)	800	800	83 (10.3)	340 (42.5)	43 (5.3)	244 (30.5)	92 (11.5)	340 (42.5)
2(2006)	800	800	N.A.	434 (54.2)	N.A.	498 (62.3)	N.A.	438 (54.7)
3(2007)	800	800	210 (26.2)	286 (35.7)	395 (49.3)	532 (66.5)	306 38.2)	422 (52.7)
4(2007)	800	800	281 (35.1)	374 (46.8)	465 (58.1)	617 (77.1)	329 41.1)	518 (64.8)
5(2008)	800	800	247 (30.8)	440 (55)	466 (58.2)	574 (71.8)	343(42.8)	450 (56.3)
6(2008)	800	800	275 (34.3)	490 (61.3)	554 (69.2)	690 (86.3)	446 55.7)	634 (79.3)
7(2009)	800	800	274 (34.0)	483 (60.3)	349 (44.0)	540 (67.5)	391(48.8)	518 (64.7)
8(2009)	800	800	356 (44.5)	594 (74.0)	415 (51.8)	624 (78.0)	333(41.6)	527 (65.8)
9(2010)	800	800	422 (52.8)	673(84.1)	329 (41.1)	534 (66.8)	287(35.9)	534 (66.8)
10(2010)	800	800	502(62.7)	635(79.3)	368(46)	575(71.8)	411(51.3)	602(75.2)
11(2011)	800	800	398(49.75)	617(77.1)	356(44.5)	600(75)	333(41.6)	568(71.5)

AndhraPradesh/Telangana (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1/12(2011)	3600	3600	1043(29.0)	2396(66.5)	648(18.0)	2030(56.4)	419(13.1)	1709(47.5)
2/13(2012)	3480	3480	1435(41.2)	2381(68.4)	1026(29.5)	2054(59.0)	595(17.1)	1499(43.1)
3/14(2012)	3600	3600	1392(38.6)	2498(69.3)	750(20.8)	1661(46.1)	393(10.9)	1162(32.2)
4/15(2013)	3600	3600	1364(38.0)	2354(65.4)	1356(37.7)	2821(78.4)	1663(46.2)	2788(77.4)
5/16(2013)	3600	3600	1546(42.9)	2478(68.6)	2292(63.6)	3153(87.5)	2574(71.5)	3239(89.9)
Telangana								
6/17(2014)	1400	1400	902(64.4)	1194(85.2)	813(58.0)	1095(78.2)	873(62.3)	1118(79.8)
7/18(2014)	1400	1400	1084(77.4)	1329(94.9)	1168(83.4)	1324(94.5)	1085(77.5)	1335(95.3)
8/19(2015)	1400	1400	1243(88.7)	1327(94.7)	1098(78.4)	1250(89.2)	1217(86.9)	1310(93.5)
9/20(2015)	1400	1400	1145(81.7)	1312(84.7)	1038(74.1)	1282(91.5)	1187(84.7)	1328(94.8)
10/21(2016)	1680	1636	1122(66.8)	1254(76.7)	965(57.4)	1168(71.4)	1100(65.5)	1215(74.3)
11/22(2017)	1680	1680	1041(61.9)	1307(77.8)	834(56.4)	1160(69.0)	972(57.9)	1332(79.3)
12/23(2017)	1795	1732	1311(73.0)	1505(86.9)	1059(60.0)	1252(72.3)	1168(65.1)	1412(81.5)
13/24(2018)	1795	1785	1003(55.9)	1355(75.9)	795(44.3)	1244(69.7)	954(53.1)	1328(74.4)
14/25(2018)	1720	1720	846(49.2)	1346(78.3)	649(37.7)	1090(63.4)	905(52.6)	1320(76.7)

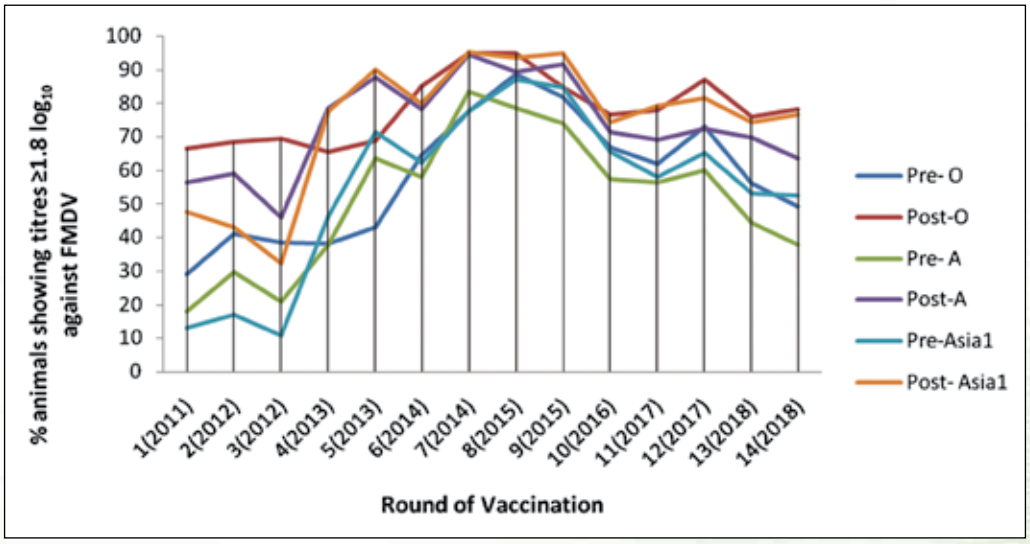


Fig. 9.5b: *Percent animals showing protective antibody titre against different serotypes.*

State of Maharashtra

Six districts of Maharashtra, namely Ahmadnagar, Aurangabad, Pune, Satara, Mumbai and Thane were covered under FMDCP in Phase I since the year 2004, and later, remaining 30 districts were included in Phase II, since the year 2011.

- A total of 97,015 pre-vac and 93,389 post-vac samples have been tested till now.
- At the end of the 13th round, pre-vac titre is low at 30-44% and Post-vac seroconversion is also low at 49-60%.
- Compared to 12th round, improvement was observed
- The state has no incidence of FMD for two consecutive years (2016-18), and this is supported by significant drop in DIVA reactivity to <6% during 2017-18 from 26% in the previous year.

Table 9.6a: ***Seroconversion and Herd immunity in Maharashtra***

Maharashtra (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2006)	844	761	173 (20.5)	456 (59.9)	151(17.9)	437 (57.4)	192 (22.8)	466 (61.2)
2(2007)	834	834	N.A.	508 (60.9)	N.A.	490 (58.6)	N.A.	553 (66.2)
3(2007)	753	799	184 (24.4)	438 (54.8)	351 (46.8)	580 (72.7)	262 (34.7)	534 (66.9)
4(2008)	789	797	191 (24.2)	417 (52.3)	517 (65.6)	679 (85.3)	278 (35.2)	509 (63.9)
5(2008)	802	772	142 (17.7)	271 (35.1)	353 (44.2)	477 (62.3)	121 (15.0)	245 (31.8)
6(2009)	901	928	404 (44.9)	663 (71.4)	622 (69.0)	853 (91.9)	245 (27.2)	446 (48.1)
7(2009)	1000	1000	446 (44.6)	692 (69.2)	701 (70.1)	893 (89.3)	431 (43.1)	667 (66.7)
8(2010)	1000	1000	646 (64.6)	904 (90.4)	574 (57.4)	848 (84.8)	198 (19.8)	452 (45.2)
9(2010)	1000	1000	730(73.0)	951(95.1)	524(52.4)	817(81.7)	324(32.4)	695(69.5)
10(2011)	1000	1000	785(78.5)	978(97.8)	686(68.6)	935(93.5)	607(60.7)	846(84.6)
11(2011)	1000	1000	558(55.8)	916(91.6)	534(53.4)	871(87.1)	403(40.3)	837(83.7)

Maharashtra (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1/12(2011)	5988	6018	1687(28.2)	4390(72.9)	941(15.7)	3080(51.2)	382(6.4)	2310(38.4)
2/13(2012)	7208	7341	1849(25.7)	4890(66.6)	481(05.8)	2530(34.5)	491(6.8)	2279(31)
3/14(2012)	4721	4723	938(20.0)	2674(56.6)	1444(30.6)	2933(62.1)	2674(31.6)	3096(65.6)
4/15(2013)	5250	5305	1673(31.0)	3746(70.6)	2641(50.3)	4429(83.5)	2809(53.5)	4513(85.1)
5/16(2013)	4891	4891	3027(61.9)	4523(92.5)	3466(70.9)	4619(94.4)	2701(55.2)	4307(88.1)
6/17(2014)	5362	5362	3285(61.3)	4959(92.5)	2312(43.1)	4438(82.8)	1902(35.5)	4112(77.0)
7/18(2014)	4181	4181	2973(71.1)	3888(93.0)	2398(57.4)	3721(89.0)	2491(60.0)	2708(65.0)
8/19(2015)	5486	5486	3317(60.5)	4905(89.4)	3726(67.9)	5119(93.3)	3684(67.2)	5149(93.9)
9/20(2015)	4903	4876	2269(46.3)	3269(67.0)	1418(28.9)	2533(51.9)	1909(38.9)	2960(60.7)

10/21(2016)	5306	5306	3508(66.1)	4023(75.8)	2452(46.2)	3129(59.0)	2878(54.2)	3561(67.1)
11/22(2017)	6108	5918	2745(44.9)	3958(66.9)	2001(32.8)	3408(57.6)	2531(41.4)	3598(60.8)
12/23(2018)	5765	5734	2317(40.2)	3296(57.5)	1569(27.2)	2578(44.9)	2098(36.4)	2924(50.9)
13/24(2018)	3846	2039	1698(44.1)	1203(59.0)	1147(29.8)	1001(49.0)	1475(38.4)	1214(59.5)

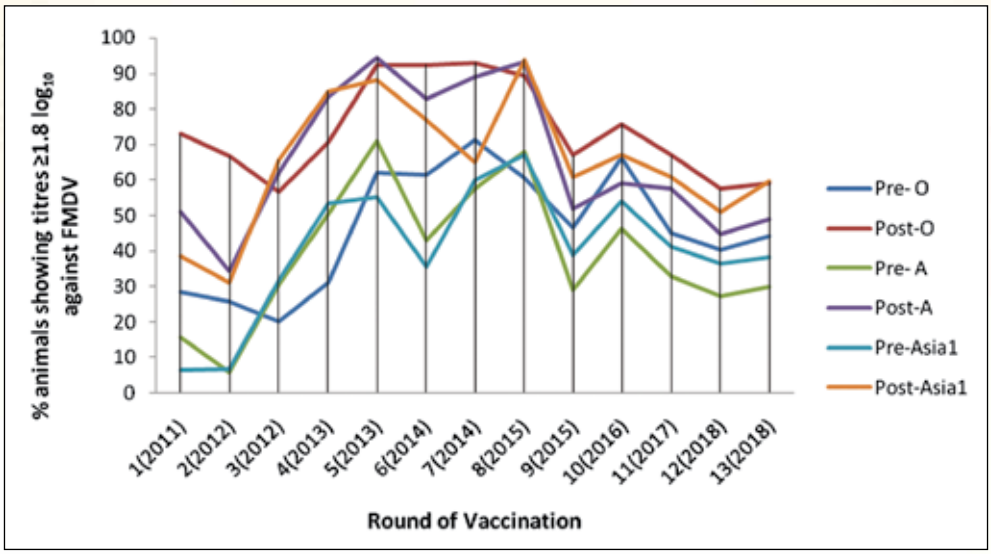


Fig. 9.6b: *Percent animals showing protective antibody titre against different serotypes.*

State of Gujarat

Four districts of Gujarat, *viz.*, Banaskantha, Sabarkantha, Mehsana and Patan were covered under FMDCP in Phase I since the year 2004-05 and remaining 29 districts were included in Phase II since the year 2011.

- A total of 56,192 pre-vac and 56,414 post-vac samples have been tested till now.
- Pre-vac titre is low at 15-24% at the end of 12 the round. Similarly post-vac titre also found to be low at 38-50%
- Compared to 11th round slight increase of antibody titre was observed in post-vac titre

Table 9.7a: ***Seroconversion and Herd immunity in Gujarat***

Gujarat (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2006)	382	259	50 (19.1)	116 (44.7)	59 (24.5)	128 (48.7)	42 (16.1)	114 (43.5)
3(2006)	442	357	123 (27.8)	171 (47.9)	171 (39.2)	268 (58.3)	51 (12.4)	149 (35.4)
4(2007)	497	456	113 (22.7)	277 (60.7)	184 (40.7)	355 (81.2)	73 (14.6)	218 (46.8)
5(2007)	195	202	46 (23.6)	99 (49.0)	126 (66.1)	179 (91.6)	44 (26.5)	92 (51.3)
6(2008)	395	395	119 (30.1)	223 (56.4)	249 (63.0)	317(80.2)	195 (49.3)	240 (60.7)
7(2008)	800	800	434 (54.3)	630 (78.8)	385 (48.1)	559 (69.9)	344 (43.0)	556 (69.5)
8(2009)	800	800	191 (23.9)	394 (49.3)	197 (24.6)	357 (44.6)	264 (33.0)	403 (50.4)

9(2009)	800	800	230(28.7)	618(77.2)	284(35.5)	572(71.5)	326(40.7)	595(74.4)
10(2010)	800	800	356(44.5)	620(77.5)	286(35.7)	525(65.6)	276(34.5)	535(66.9)
11(2010)	800	800	55(27.5)	76(38.0)	44(22.0)	71(35.5)	29(14.5)	49(24.5)
12(2011)	800	800	104(52.0)	105(52.5)	80(40.0)	67(33.5)	56(28.0)	25(12.5)

Gujarat (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 $\log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1/13(2011)	2007	2029	589(29.4)	1009(49.7)	407(20.3)	784(38.6)	670(33.4)	1011(49.8)
2/14(2012)	3974	4290	1748(44.0)	2545(59.3)	1354(34.1)	2224(51.8)	1393(35.1)	2095(48.8)
3/15(2013)	4700	4708	2652(56.4)	3164(67.2)	2237(47.6)	2946(62.6)	2245(47.8)	2754(58.5)
4/16(2013)	4600	4538	2506(54.5)	3444(75.9)	2874(62.5)	3491(76.9)	3183(69.2)	3688(81.3)
5/17(2014)	5200	5200	3093(59.5)	3869(74.4)	3260(62.7)	3971(76.4)	3376(74.9)	4160(80.0)
6/18(2014)	3600	3600	2695(74.9)	2937(81.6)	1786(49.6)	2369(65.8)	2722(65.6)	2861(79.5)
7/19(2015)	5000	5000	3000(60.0)	3556(73.1)	3081(61.6)	3728(74.6)	3620(72.4)	4031(80.6)
9/21(2016)	5000	5200	1573(31.5)	3036(58.4)	1222(24.4)	2422(46.6)	1287(25.7)	2777(53.4)
10/22(2017)	5000	5000	1583(31.7)	2885(57.7)	1193(23.9)	2400(48.0)	1215(24.3)	2629(52.6)
11/23(2017)	5200	5200	1386(26.7)	2338(45.0)	1025(19.7)	1844(35.5)	1331(25.6)	2256(43.4)
12/24(2018)	5200	5180	1172(22.5)	2522(48.7)	821(15.8)	1967(38.0)	1258(24.2)	2566(49.5)

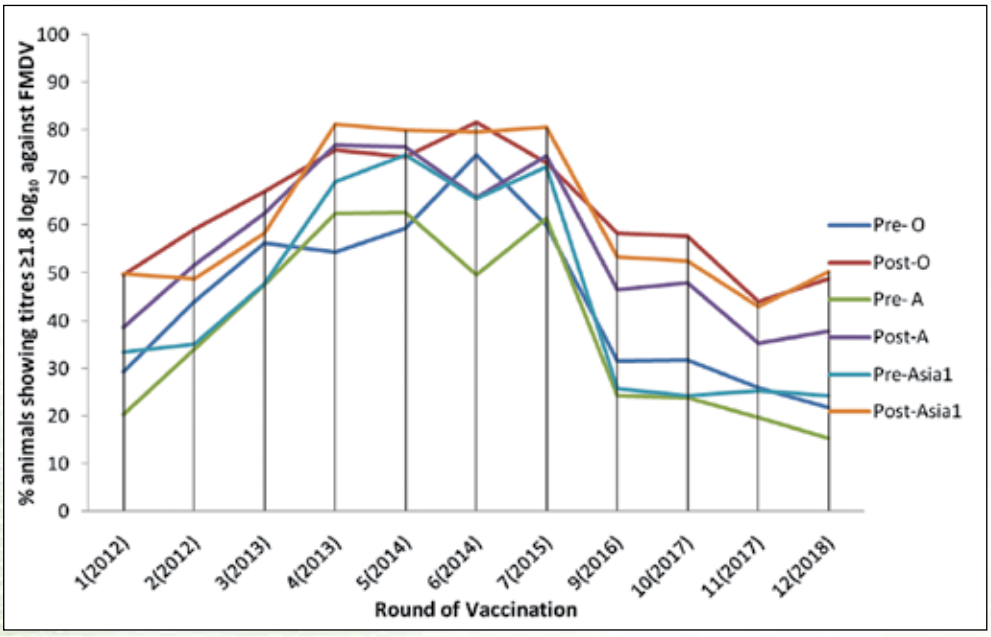


Fig. 9.7b: *Percent animals showing protective antibody titre against different serotypes.*

State of Rajasthan

The entire state of Rajasthan was covered under FMDCP in Phase III since the year 2014.

- A total of 19,212 pre-vac and 15,936 post-vac samples have been tested till now.
- At the end of 6th round, pre-vac titre is found to be 17-26% and post-vac titre is 32-45%
- Since only 6 rounds has been completed, it is expected to improve subsequently

Table 9.8a: *Sero-conversion and Herd immunity in Rajasthan*

Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1&2 (2015)	4496	2298	2246(49.9)	1915(83.3)	2485(55.3)	1634(71.1)	2516(55.9)	1657(72.1)
3(2016)	1117	238	750 (67.1)	229 (96.2)	827 (74.0)	198 (83.2)	1023 (91.6)	213 (89.5)
5(2017)	6800	6600	2110(31.0)	3605(54.6)	1969(29.0)	3378(51.2)	1528(22.5)	2949(44.7)
6(2018)	6799	6800	1784(25.7)	3059(45.0)	1186(17.4)	2268(33.4)	1360(20.0)	2167(31.9)

State of Odisha

The entire state of Rajasthan was covered under FMDCP in Phase III since the year 2017.

- A total of 11,213 pre-vac and 10,689 post-vac samples have been tested till now.
- At the end of 3rd round, pre-vac titre is found to be good at 18-34%
- Post-vac titre is also found to be very good at 34-51%
- Since only 3 rounds has been completed, it is expected to further improve

Table 9.9a: *Sero-conversion and Herd immunity in Odisha*

Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2017)	1753	1591	418(23.8)	936(58.8)	258(14.7)	715(44.9)	300(17.1)	809(50.8)
2(2018)	3600	3378	949(26.4)	1617(47.9)	594(16.5)	1197(35.4)	806(22.4)	1509(44.7)
3(2018)	5860	5720	1999(34.1)	2935(51.3)	1043(17.8)	1931(33.8)	1621(27.7)	2286(39.9)

State of Chhattisgarh

- A total of 6454 pre-vac and 7447 post-vac samples have been tested till now.
- At the end of 2nd round, pre-vac titre is found to be good at 18-35%
- Post-vac titre is also found to be very good at 34-51%
- Since only 2 rounds has been completed, it is expected to further improve

Table 9.10a: *Sero-conversion and Herd immunity in Chhattisgarh*

Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2017)	2937	3676	858(29.2)	1614(43.9)	508(17.3)	1153(31.4)	821(27.9)	1445(39.3)
2(2018)	3517	3771	1170(33.3)	1800(47.7)	626(17.8)	1291(34.2)	1214(34.5)	1915(50.8)

State of Punjab

Eight districts of Punjab namely, Amritsar, Bhatinda, Fatehgarh Sahib, Ferozpur, Mansa, Sangrur, Patiala and Gurdaspur were covered under FMDCP in Phase I since the year 2004, and remaining 14 districts were included in Phase II since 2011.

- A total of 60,638 pre-vac and 59,986 post-vac samples have been tested till now.
- At the end of 13th round pre-vac titre is low at 27-31% and similarly post-vac titre also low at 38-46%
- The herd immunity needs to be improved

Table 9.11a: *Seroconversion and Herd immunity in Punjab*

Punjab (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2007)	-	742	N.A.	187(25.2)	N.A.	90(11.5)	N.A.	273(49.5)
2(2007)	-	500	N.A.	219(43.8)	N.A.	113(20.9)	N.A.	279(58.1)
3(2008)	1084	1365	915(84.4)	1175(86.1)	816(75.3)	1007(73.8)	437(40.2)	573(42.0)
4(2008)	1291	978	988(76.5)	792 (81.0)	794(61.5)	627 (64.1)	694 (53.8)	356(36.4)
5(2009)	1370	1139	477(34.8)	621(54.5)	445(32.8)	630(53.7)	513(38.5)	690(60.1)
6(2009)	1509	1568	653 (43.3)	944 (60.2)	654 (43.3)	921 (58.7)	496 (32.9)	743 (47.4)
7(2010)	1265	1432	520 (41.1)	898 (62.7)	356 (28.1)	639 (44.6)	448 (35.4)	696 (48.6)
8(2010)	984	1125	580(58.9)	825(73.33)	410(41.7)	643(57.2)	452(45.9)	741(65.9)
9(2011)	1558	1546	1035(66.4)	1193(77.1)	831(53.3)	978(63.4)	926(59.4)	1132(73.2)
10(2011)	1592	1592	1030(64.7)	1231(77.3)	904(56.8)	1098(67.0)	970(61.0)	1156(72.6)

Punjab (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1/11(2012)	1800	1800	797(44.3)	978(54.3)	704(39.1)	825(45.8)	615(34.2)	874(48.6)
2/12(2012)	1800	1782	1002(55.6)	1096(61.5)	902(50.1)	978(54.8)	904(50.2)	NT
3/13(2013)	1436	1195	940(65.5)	845(70.7)	900(62.7)	815(68.2)	908(63.2)	977(81.7)
4/14(2013)	2287	2110	1271(55.6)	1592(75.5)	1557(68.1)	1030(48.8)	1707(74.6)	1849(87.6)
5/15(2014)	1975	1705	1088(55.1)	1162(68.2)	1359(68.8)	1389(81.5)	1660(84.1)	1602(94.0)
6/16(2014)	1872	1990	1248(66.7)	1416(71.2)	1423(76.0)	1606(80.7)	1582(84.5)	1832(92.1)
7/17(2015)	2126	2105	1442(67.8)	1595(75.8)	1363(64.1)	1567(74.4)	1365(64.2)	1626(77.7)
8/18(2015)	2400	2289	1724(71.8)	1824(79.7)	1577(65.7)	1692(73.9)	1444(60.2)	1608(70.2)
9/19(2016)	698	-	490 (70.8)	-	462 (66.2)	-	478 (68.5)	-
10/20(2016)	2352	2087	1498(63.7)	1588(76.1)	1155(49.1)	1298(62.2)	1445(61.4)	1466(70.2)
11/21(2017)	2654	3043	1100(41.4)	1898(62.4)	1083(40.8)	1693(55.6)	1078(40.5)	1684(55.3)
12/22(2018)	3921	3934	1588(40.5)	2508(63.8)	1350(34.4)	2312(58.8)	1440(36.7)	1995(50.7)
13/23(2018)	3815	3902	1199(31.4)	1523(39.0)	1169(30.6)	1791(45.9)	1020(26.7)	1486(38.1)

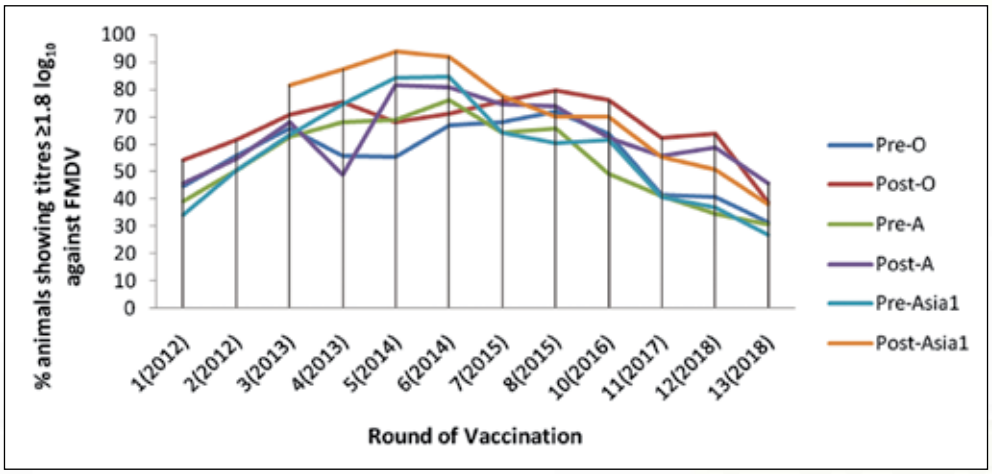


Fig. 9.11b: *Percent animals showing protective antibody titre against different serotypes.*

State of Haryana

Eight districts of Haryana namely, Bhiwani, Fatehabad, Hisar, Jhajjar, Jind, Rohtak, Sirsa and Sonipat were covered under FMDCP in Phase I since the year 2004, and remaining 14 districts were included in Phase II since the year 2011.

- A total of 55,311 pre-vac and 52,038 post-vac samples have been tested till now.
- Herd immunity is good in phase I districts at >74%, and that in phase II district is at >67%, that speaks of efficient vaccination in the state.
- Further, there have been sporadic incidences of FMD since 2013-14, and this has resulted in increase in DIVA reactivity subsequent to 2013-14 (2.1%), and during 2017-18, the DIVA reactivity is very high at >32%. The matter is serious, and vaccination has to be intensified to keep control on FMD in Haryana.

Table 9.12a: *Seroconversion and Herd immunity* in Haryana

Haryana (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 $\log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2005)	1600	1525	627(39.2)	946(62.0)	398(24.9)	860(56.4)	227(14.2)	862(56.5)
2(2005)	-	1558	-	1065(68.3)	-	859 (55.1)	-	831 (53.3)
3(2006)	-	1583	-	1146(72.3)	-	1007(63.6)	-	1005(63.4)
4(2006)	1584	1552	953 (60.1)	1222(78.7)	668 (42.1)	887 (57.1)	844(53.2)	1170(75.3)
5(2008)	1599	1599	955 (59.7)	1352(84.5)	813 (50.8)	1274(79.6)	941(58.8)	1353(84.5)
6(2008)	1495	1498	995 (66.5)	1306(87.1)	895 (59.8)	1229(82.0)	844(56.4)	1118(74.6)
7(2009)	1562	1574	856(54.8)	1296 (82.3)	1021(65.3)	1380(87.6)	888 (56.8)	1317 (83.6)
8(2009)	1547	1540	949(61.3)	1289 (83.7)	877 (56.6)	992 (64.4)	765 (49.4)	1101 (71.4)
9(2010)	1497	1476	647(43.2)	1140(77.2)	590(39.4)	1022(69.2)	410(27.4)	879(59.6)
10(2010)	1420	1440	851(59.9)	1350(93.8)	615(43.3)	1003(69.7)	587(41.3)	1145(79.5)
11(2011)	1500	1464	734(48.9)	1302(88.9)	546(36.4)	1180(80.6)	455(30.3)	1109(75.8)
12(2011)	1480	1330	647(43.7)	1050(78.9)	562(38.0)	1073(80.7)	507(34.3)	948(71.2)
13(2012)	1590	1600	925(58.2)	1332 (83.3)	950(59.8)	1330(83.1)	663(41.7)	1133(70.8)
14(2012)	1580	1580	627(39.7)	1327(84.0)	594(37.6)	1279(81.0)	536(33.9)	1272(80.5)
15(2013)	1600	1600	963(60.2)	1286(80.4)	856(53.5)	1207(75.4)	724(45.3)	1182(73.9)
16(2013)	1600	1600	913(57.1)	1335(83.4)	813(50.8)	1351(84.4)	983(61.4)	1409(88.1)
17(2014)	1597	1600	935(58.5)	1434(89.6)	1044(65.4)	1460(91.3)	1323(82.8)	1556(97.3)
18(2014)	1600	1600	1153(72.1)	1547(96.7)	1020(63.7)	1476(92.3)	1106(69.1)	1541(96.3)
19(2015)	1600	1600	1332(83.3)	1569(98.1)	1305(81.6)	1546(96.6)	1327(82.9)	1590(99.4)
20(2015)	1600	1000	1195 (74.7)	956 (95.6)	1151 (71.9)	909 (90.9)	1341 (83.8)	979 (97.9)

Haryana (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2011)	2587	2573	1105(42.7)	1979(76.9)	838(32.4)	1796(69.8)	769(29.7)	1586(61.6)
2(2011)	2586	2594	1081(41.8)	1876(73.5)	986(38.1)	1876(73.4)	727(28.1)	1537(60.2)
3(2012)	2555	2562	1092(42.5)	1809(71.2)	1113(43.3)	1856(73.1)	650(25.3)	1576(62.1)
4(2012)	2565	2575	1043(40.1)	2049(79.5)	893(34.8)	1811(70.3)	840(32.7)	1700(66)
5(2013)	2600	2600	1210(46.5)	1867(71.8)	1178(45.3)	1638(63)	1010(39.0)	1709(66)
6(2013)	2580	2580	1171(45.4)	2063(80.0)	1455(56.4)	2161(83.8)	1865(72.3)	2341(90.7)
7(2014)	2558	2597	1755(68.0)	2285(88.0)	1895(74.1)	2160(83.2)	2050(80.1)	2483(95.6)
8(2014)	2600	2600	1987(76.4)	2427(93.3)	1907(73.3)	2371(91.2)	2138(82.2)	2506(96.4)
9(2015)	2600	2600	2113(81.3)	2447(94.1)	2112(81.2)	2439(93.8)	2208(84.9)	2542(97.8)
10(2015)	2000	200	1347 (67.4)	192 (96.0)	1343 (67.2)	191 (95.5)	1555 (77.8)	199 (99.5)

State of 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 since the year 2004, and remaining 59 districts was included in Phase III since 2014.

- A total of 63,784 pre-vac and 52,494 post-vac samples have been tested till now.
- Herd immunity as well as seroconversion following 7th round of vaccination is poor.

  Both values were <33%.

Table 9.13a: *Seroconversion and Herd immunity* in Uttar Pradesh

Uttar Pradesh (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2(2007)	139	407	0(0)	180(44.2)	0(0)	155(38.1)	0(0)	293(72.0)
3(2007)	1155	1584	399(34.5)	780(49.2)	494(42.7)	910(57.4)	490(42.4)	1138(71.8)
4(2008)	1910	1770	344(18.0)	537(30.3)	610(31.9)	866(48.9)	519(27.2)	808(45.6)
5(2008)	1440	1591	516(35.8)	715(44.9)	625(43.4)	802(50.4)	684(47.5)	786(49.4)
6(2009)	1488	1579	514(34.5)	968 (61.3)	520 (34.9)	826 (52.3)	400 (26.9)	838 (53.1)
7(2009)	2833	2075	706 (24.9)	911 (43.9)	597 (21.1)	808 (38.9)	740 (26.1)	930 (44.8)
8(2010)	1904	2744	707(37.1)	1550(56.5)	502(26.4)	1310(47.7)	617(32.41)	1288(46.9)
9(2010)	2762	3002	927(33.5)	1198(39.9)	617(22.3)	1095(36.5)	597(21.6)	1072(35.7)
11(2011)	643	2206	47(7.3)	481(21.8)	68(10.6)	321(14.6)	385(59.9)	1103(50)
12(2011)	1934	1535	184(9.5)	270(17.6)	252(13)	524(34.1)	424(21.9)	773(50.6)
13(2012)	983	2946	146(15)	955(32.4)	69(7.7)	780(26.5)	220(22.4)	1054(35.8)

14(2012)	4041	3800	2473(61.2)	2522(66.4)	2501(62)	2139(56.3)	2501(62)	1107(29)
15(2012)	3870	3968	1641(42.4)	2260(57)	1312(33.9)	2256(56.9)	1507(38.9)	2626(66.2)
16(2013)	10763	3648	4114(38.2)	1375 (37.7)	4527(42.1)	1584 43.4)	4570(42.5)	1834 (50.3)
17(2013)	8840	NA	2721 (30.8)	NA	4343(49.1)	NA	5595(63.3)	NA

Uttar Pradesh (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
6(2017)	8904	9125	1829(20.5)	3139(34.4)	1398(15.7)	2582(28.3)	1785(20.0)	3174(34.8)
7(2018)	11568	11627	1966(16.7)	3580(30.8)	1603(13.9)	2847(24.5)	2185(18.9)	3768(32.4)

State of Uttarakhand

- The state of Uttarakhand has been covered under FMDCP since the year 2017
- A total of 4656 pre-vac and 3147 post-vac samples have been tested till now.
- At the end of 3rd round, pre-vac titre is found to be low at 9-15%
- Post-vac titre is also found to be low at 19-19%
- Since only 3 rounds has been completed, it is expected to further improve

Table 9.14a: *Seroconversion and Herd immunity* in Uttarakhand

Uttarakhand								
Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2017)	1021	941	164(16.0)	175(18.6)	94(9.2)	92(9.8)	123(12.0)	126(13.4)
2(2017)	1519	703	282(18.6)	123(17.5)	396(26.1)	85(12.1)	405(26.7)	85(12.1)
3(2018)	2116	1503	317(14.9)	281(18.7)	184(8.7)	152(10.1)	250(11.8)	187(12.4)

State of West Bengal

- The state of west Bengal has been covered under FMD-CP since the year 2017
- A total of 9467 pre-vac and post-vac samples have been tested till now.
- At the end of 3rd round, pre-vac titre is found to be low at 11-23%
- Post-vac titre is found to be good at 23-43%
- Since only 3 rounds has been completed, it is expected to further improve

Table 9.15a: *Seroconversion and Herd immunity* in West Bengal

West Bengal								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2017)	1141	1141	306(26.8)	409(35.8)	197(17.3)	251(22.0)	223(19.5)	310(27.2)
2(2017)	3726	3726	717(19.2)	1509(40.5)	487(13.1)	4945(25.4)	419(11.2)	860(23.1)
3(2018)	4600	4600	1954(22.9)	1957(42.5)	522(11.3)	1052(22.9)	711(15.5)	1332(29.0)

State of Bihar

- The state of Bihar has been covered under FMD-CP since the year 2015
- A total of 4328 pre-vac and 6955 post-vac samples have been tested till now.
- At the end of 5th round, pre-vac titre is found to be very low at 2.2-3.6%
- Post-vac titre also found to be very low at 6-9%

Table 9.16a: *Seroconversion and Herd immunity* in Bihar

Bihar								
Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
4(2017)		2941		325(11.0)		229(7.8)		141(4.8)
5(2018)	3952	4014	142(3.6)	373(9.3)	95(2.4)	290(7.2)	86(2.2)	223(5.6)

State of Madhya Pradesh

Table 9.17a: *Seroconversion and Herd immunity* in Madhya Pradesh

Madhya Pradesh								
Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2(2017)	10158	10176	1549(15.2)	3230(31.7)	1032(10.2)	2361(23.2)	1195(11.8)	3067(30.1)

State of Goa

Goa was included under FMD-CP in Phase II since 2011.

- A total of 5392 pre-vac and 5358 post-vac samples have been tested till now.
- The herd immunity is low at 26-38% at 14th round, so also the seroconversion following vaccination is low (41-50%).
- One incidence due to serotype Asia1 in 2011-12 and two incidences due to serotype A in 2013-14 was recorded.

Table 9.18a: *Seroconversion and Herd immunity* in Goa

Goa								
Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2012)	391	381	47(12)	244(86.8)	8(2)	92(24.1)	11(2.8)	92(24.1)
2(2012)	383	378	159(41.5)	316(84)	59(15.4)	234(62)	175(46)	331(88)
3(2013)	384	368	182(47.4)	302(82.1)	241(64.3)	317(86.1)	209(54.4)	316(86)
4(2013)	379	376	171(45.1)	289(77)	222(58.5)	323(86)	215(57)	320(85.1)
5(2014)	375	375	322(85.9)	371(98.9)	289(77.1)	361(96.3)	194(51.7)	338(90.1)
6(2014)	371	371	264(71.2)	362(97.6)	211(56.9)	338(91.1)	235(63.3)	343(92.5)
7(2015)	369	369	241(65.3)	343(93.0)	250(67.8)	362(98.1)	282(76.4)	364(98.6)
8(2015)	383	383	248(64.8)	288(75.2)	171(44.6)	235(61.4)	182(47.5)	274(71.5)
9(2016)	362	362	252(69.6)	266(73.5)	137(37.8)	232(64.0)	191(52.8)	236(65.2)
10(2016)	395	395	249(63.0)	250(63.3)	168(42.5)	204(51.6)	209(52.9)	236(59.7)
11(2017)	400	400	173(43.3)	287(71.8)	132(33.0)	273(68.3)	146(36.5)	268(67.0)
12(2017)	400	400	174(43.5)	259(64.8)	119(29.8)	223(55.8)	132(33.0)	232(58.0)
13(2018)	400	400	146(36.5)	174(43.5)	139(34.8)	156(39.0)	153(38.3)	173(43.3)
14(2018)	400	400	125(31.3)	199(49.8)	105(26.3)	164(41.0)	153(38.3)	194(48.5)

Delhi

Delhi was included under FMD-CP in Phase I since the year 2004.

- A total of 1466 pre-vac and 1371 post-vac samples have been tested till now.
- Herd immunity was good at 69-81% with a higher seroconversion following vaccination at 92% after 19th round of vaccination.
- This observation commensurate with absolutely no incidence of FMD in Delhi for last more than 5 years, in spite of higher traffic of lactating animals.
- Delhi had always higher seroconversion than any other state in the country since 2008, and this is attributed proper and regular vaccination in the state.
- Data reveals that strong herd immunity is a deterrent for virus incursion.
- Delhi is the best success story for the FMDCP and clearly justifies that regular vaccination in time and density can achieve freedom from FMD.

Table 9.19a: *Seroconversion and Herd immunity* in Delhi

Delhi								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2008)	50	50	26 (53)	50 (100)	13 (26)	47 (94)	17 (34)	48 (96)
2(2008)	24	24	22 (91)	23 (96)	12 (40)	15 (62)	23 (95)	22 (86)
3(2009)	50	50	47 (94)	49 (98)	30 (60)	40 (80)	43 (86)	46 (92)
4(2009)	50	46	38 (76)	38 (82.6)	14 (28)	40 (86.9)	27 (54)	41 (89.1)
5(2010)	44	53	26 (59)	47 (88.6)	23 (52.2)	37 (69.8)	32 (72.7)	41 (77.3)
6(2010)	98	98	76 (77.5)	97 (98.9)	60 (61.2)	93 (94.9)	71(72.4)	97 (98.9)
7(2011)	50	50	39(78)	44(88)	33(66)	43(86)	25(50)	41(82)
8(2011)	100	100	92 (92)	100 (100)	66 (66)	86 (86)	83 (83)	98 (98)
9(2012)	100	NA	57(57)	NA	65(65)	NA	33(33)	NA
11(2012)	200	NA	172(86)	NA	100(50)	NA	91(45.5)	NA
13(2013)	100	100	98(98)	98(98)	95(95)	100(100)	87(87)	100(100)
14(2013)	NA	200	NA	170(85)	NA	179(89.5)	NA	153(76.5)
15(2014)	200	200	157(78.5)	171(85.5)	124(62)	158(79)	143(71.5)	156(78)
18(2014)	200	200	154(77)	196(98)	107(53.5)	177(88.5)	161(80.5)	193(96.5)
19(2015)	200	200	137 (68.5)	184 (92)	140 (70)	184 (92)	162 (81)	183 (91.5)

Lakshadweep:

Lakshadweep was included under FMD-CP in Phase II since 2011

Table 9.20a: *Seroconversion and Herd immunity* in Lakshadweep

Lakshadweep								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2012)	107	107	45(42.1)	80(74.8)	16(15)	63(58.9)	35(32.7)	50(46.7)

No serum sample received from Lakshadweep after 2012

Puducherry

Pondicherry was included under FMD-CP in Phase II since 2011.

- A total of 1960 pre-vac and 1982 post-vac samples have been tested till now.
- The herd immunity is good at 41-83% at 15th round, so also the seroconversion following vaccination is good (70-93%).

Table 9.21a: *Seroconversion and Herd immunity* in Puducherry

Puducherry								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2012)	30	55	16(44.4)	24(66.7)	9(25.0)	20(55.6)	5(13.9)	11(30.6)
2(2012)	38	38	16(42.1)	20(52.6)	10(26.3)	14(36.8)	-	18(21.1)
3(2013)	46	46	21(45.7)	29(63.0)	7(15.2)	20(43.5)	26(56.5)	30(65.2)
6(2014)	246	246	214(87.0)	237(96.3)	182(74.0)	232(94.3)	213(87)	235(95.5)
7(2015)	243	243	231(95.1)	233(96.0)	147(60.4)	209(86.0)	225(93)	231(95.1)
11(2016)	275	275	242(88.0)	261(94.9)	202(73.5)	238(86.5)	236(85.8)	255(92.7)
12(2017)	265	265	254(95.8)	260(98.1)	227(85.7)	238(89.8)	251(94.7)	253(95.5)
13(2017)	281	278	165(58.7)	210(75.5)	140(49.8)	169(60.8)	194(69.0)	218(78.4)
14(2018)	248	248	173(69.8)	204(82.3)	123(49.6)	199(80.2)	182(73.4)	221(89.1)
15(2018)	288	288	184(63.9)	212(73.6)	119(41.3)	201(69.8)	240(83.3)	269(93.4)

Andaman & Nicobar Island

Eight villages of Andaman & Nicobar were covered under FMDCP in Phase I since the year 2004, and later entire Andaman & Nicobar Island was included in Phase II since the year 2011.

- A total of 7387 pre-vac and 6275 post-vac samples have been tested till now.
- The herd immunity is low at 13-23% at 15th round, so also the seroconversion following vaccination is low (27-43%).

Table 9.22a *Seroconversion and Herd immunity* in Andaman & Nicobar Islands

Round of vaccination	Number of serum samples		Number & % animals showing titres ≥1.8 log_{10} against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
3(2007)	154	162	40(25.9)	97(60)	5(2.8)	37(20.3)	52(34.0)	118(73.6)
4(2008)	149	146	50(33.5)	94(64.6)	50(33.5)	96(65.9)	35(23.4)	101(67.6)
5(2008)	126	122	72(57.2)	68(55.8)	62(50.8)	64(52.5)	54(44.3)	62(50.8)
6(2009)	270	270	50 (18.5)	80 (29.6)	66 (24.4)	104 (38.4)	28 (10.2)	36 (13.2)
7(2009)	265	265	112 (42.3)	174 (65.7)	82 (30.9)	110 (41.5)	56 (21.1)	66 (24.9)
8(2010)	251	251	53(21.11)	102(40.63)	18(7.2)	49(19.52)	47(18.72)	85(33.86)
9(2010)	228	228	73(32.01)	69(30.26)	31(13.5)	35(15.35)	56(24.56)	42(18.42)
12(2012)	180	180	36(20.0)	49(27.22)	19(10.5)	40(22.22)	11(6.11)	30(16.67)
13(2012)	283	283	26(9.2)	78(27.6)	12(4.2)	52(18.4)	15(5.3)	44(15.5)
14(2013)	794	593	144(18.1)	279(47)	100(12.6)	214(36.1)	77(10.0)	194(32.7)
15(2013)	1445	1109	308(21.3)	550(49.9)	333(23)	584(52.6)	433(29.9)	674(60.7)
16(2014)	530	502	220 (41.5)	312 (62.2)	243 (45.8)	398 (79.3)	251(50.0)	394 (74.3)
17(2014)	521	461	225(42.3)	354(69.2)	302(58.0)	376(82)	286(55.0)	259(78)

18(2015)	609	496	383 (62.9)	408 (82.3)	414 (67.9)	426 (85.9)	505 (82.3)	458 (92.3)
19(2015)	556	480	337 (60.6)	351 (73.1)	355 (63.8)	422 (87.9)	404 (72.7)	416 (86.7)
20(2016)	520	386	76(14.6)	131(33.9)	85(16.4)	111(28.8)	127(24.4)	146(37.8)
21(2017)	215	67	38(17.7)	23(34.3)	32(14.9)	13(19.4)	41(19.1)	26(38.8)
22(2017)	291	274	54(18.6)	112(40.9)	46(15.8)	102(37.2)	61(20.9)	121(44.1)
23(2018)	362	319	79(21.8)	129(40.4)	46(12.7)	87(27.3)	82(22.7)	138(43.3)

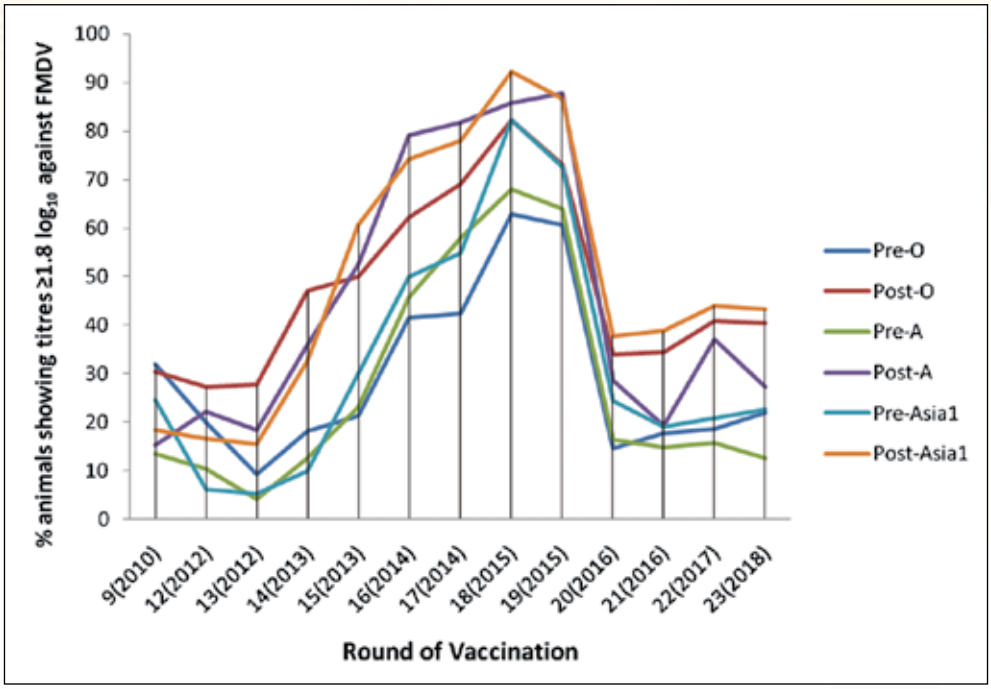


Fig 9.22b: *Percent animals showing protective antibody titre against different serotypes.*

Table 9.23 Percent protective titre range in pre and post vac samples at the end of last round

State	Round of vaccination	Year	Pre-vac titre (% protected)	Post-vac titre (% protected)
Tamil Nadu	15	2018	40-52	69-77
Karnataka	14	2018	42-47	56-65
Kerala	13	2018	41-60	69-84
Telangana	14	2018	38-53	63-78
Andhra Pradesh	15	2018	31-47	66-76
Maharashtra	12	2018	27-40	49-60
Gujarat	12	2018	15-24	38-50
Rajasthan	6	2018	17-26	32-45
Odisha	3	2018	18-34	34-51
Chhattisgarh	2	2018	18-35	34-51
Uttar Pradesh	7	2018	14-19	25-33
Uttarakhand	3	2018	9-15	10-19

West Bengal	3	2018	11-23	23-43
Pondicherry	15	2018	41-83	70-93
MP	2	2017	10-15	23-32
Goa	14	2018	26-38	41-50
A&N Island	23	2018	13-23	27-43
Bihar	5	2018	2-3	6-9
Punjab	13	2018	27-31	38-46

10 Production, Standardization and Supply of Diagnostic Reagents/kits

For production of reagents, the vaccine virus strains {O (INDR2/75), Asia1 (IND 63/72),) and A (IND40/00)} were bulk produced in roller culture vessels and purified by density gradient centrifugation. Antibodies against purified virus was raised and titrated against homologous as well as heterologous virus. Freeze dried and standardized serum antibodies (rabbit and guinea pig) and known positive antigen (killed) of all three serotypes were supplied to all the Regional and Collaborative Centers for use in virus Serotyping ELISA. Recombinant 3AB3 NSP kit was produced as per requirement. The kits have been supplied to the AICRP on FMD Regional and Collaborative Centers for sero-surveillance of FMD. Due to uniformity in testing system, reliable data has been generated from time to time on epidemiology of FMD in the country.

Table 10.1: Year-wise supply of diagnostic kits

Year	LPBE/SPCE	S-ELISA	DIVA
2009-10	80,000	7,000	54,485
2010-11	82,800	9,000	71,940
2011-12	1,54,600	10,000	61,670
2012-13	1,77,850	16,500	85,350
2013-14	2,36,640	21,500	87,850
2014-15	2,71,960	3,000	79,800
2015-16	1,65,520	7,500	50,380
2016-17	-	6,000	94,380
2017-18	1,70,000*	4,000	75,280
2018-19	2,50,000*	5,000	70,000

*Used at FMDCP Laboratory

Research Projects

11

S. No.	Title	PI	Co-PI	Duration	Institute code
1	Assessment of persistence of foot and mouth virus in animal through meta genomic approach	A.P.Sahoo	Sagar A. Khulape R. Ranjan	2018-20	DFMD/10/2018
2	Identification of gene(s) and gene networks to unravel virus-host interactome associated with Foot and Mouth disease of cattle	A.P.Sahoo	Sagar A. Khulape Shyam S Dahiya J.K. Biswal	2018-20	DFMD/11/2018
3	Development and characterization of monoclonal antibodies to foot and mouth disease (FMD) virus serotype O	S. Mallick	J.K. Biswal Sagar A. Khulape R. Ranjan	2018-20	DFMD/12/2018
4	Foot-and-mouth disease virus surveillance at the wildlife-livestock interface	R. Ranjan	Jitendra K Biswal	2019-21	DFMD/1/2019
5	Development, standardization and quality control of biosecurity procedures at BSL3+Ag laboratory of International Centre for Foot-and-mouth disease virus	R. Ranjan	Jitendra K Biswal	2019-20	DFMD/2/2019
6	Development of DIVA-compatible live-attenuated vaccine candidate strain for FMDV serotype O	Jitendra K Biswal	Saravanan S R. Ranjan	2019-21	DFMD/3/2019
7	Development and in vitro characterisation of thermostable vaccine candidates for FMDV serotypes Asia1 and A	Jitendra K Biswal	Saravanan S Sagar A. Khulape	2019-21	DFMD/4/2019
8	Genetic and antigenic characterization of foot and mouth disease virus serotype O from India during 2019-20.	Jitendra K Biswal	Saravanan S. A.P.Sahoo Shyam S Dahiya	2019-20	DFMD/5/2019
9	Genetic and antigenic characterization of Foot and Mouth Disease virus serotype Asia1 during 2019-20	Sagar A. Khulape	Saravanan S	2019-20	DFMD/6/2019
10	Heterologous expression of FMDV genome regions and proteins	Sagar A. Khulape	J. K. Biswal R. Ranjan	2019-21	DFMD/7/2019
11	Epidemiology of Foot and Mouth Disease in small ruminants and pigs in India during 2019-20.	M. Rout	J.K.Mohapatra Saravanan S	2019-20	DFMD/8/2019
12	Study of vaccine induced antibody response in livestock in organized herd	M. Rout	J.K.Mohapatra	2019-21	DFMD/9/2019

S. No.	Title	PI	Co-PI	Duration	Institute code
13	Production, standardization and supply of diagnostic reagents for Foot and Mouth Disease virus diagnosis and surveillance during 2019-20.	A P Sahoo	J.K.Mohapatra R. Ranjan S. Mallick Shyam S Dahiya	2019-20	DFMD/10/2019
14	Seromonitoring of pre and post vaccinal immunity against Foot and Mouth Disease virus during 2019-20.	J.K.Mohapatra	Saravanan S	2019-20	DFMD/11/2019
15	Assessment of prevalence of Foot and Mouth Disease during 2015-2020 in India	Saravanan S	J. K. Biswal Sagar A. Khulape Shyam S Dahiya	2019-20	DFMD/12/2019
16	Generation of monoclonal antibodies against recombinant FMDV polyprotein 3AB and their application in immunodiagnosis	Smrutirekha Mallick	A P Sahoo J K Biswal Rajeev Ranjan	2019-21	DFMD/13/2019

Publications, Awards and Honours

12

12.1: Research Papers

International

1. Sharma AK, Bhatt M, Sankar M, Mohapatra JK, Dash BB, Gowane GR, Subramaniam S, Ranjan R, Pattnaik B (2018) Kinetics of Interferon gamma and Interleukin-21 response following foot and mouth disease virus infection. Microb Pathog. 4010(18)31264-6. (NAAS-8.01; IF-2.332)

2. Mohapatra JK, Das B, Rout M, Sreenivasa BP, Subramaniam S, Sanyal A, Pattnaik B (2018) Alternate vaccine strain selection in the wake of emerging foot-and-mouth disease virus serotype A antigenic variants in India. Vaccine, https://doi.org/10.1016/j.vaccine.2018.04.090 (NAAS-9.24; IF-3.235)

3. Sarangi LN, Mohapatra JK, Subramaniam S, Das B, Sanyal A, Pattnaik B (2018). Substitutions accrued on Foot-and-mouth disease virus capsid during propagation in cell culture. Proc. Natl. Acad. Sci., India, Sect. B Biol. Sci. https://doi.org/10.1007/s40011-018-0986-9 (NAAS-4; IF-0.396)

Research papers from Inter institutional collaboration

1. Ganji VK, Biswal JK, Lalzampuia H, Basagoudanavar SH, Saravanan P, Tamil Selvan RP, Umapathi V, Reddy GR, Sanyal A, Dechamma HJ (2018). Mutation in the VP2 gene of P1-2A capsid protein increases the thermostability of virus-like particles of foot-and-mouth disease virus serotype O. **Applied Microbiology and Biotechnology**. 2018. https://doi.org/10.1007/s00253-018-9278-9. (NAAS-9.42; IF-3.340)

2. Saxena A, Biswas SK, Chand K, Chauhan A, Mohd G, Subramaniam S, Naskar J, Mondal B, Ramakrishnan MA, Pandey AB (2019). Genetic characterization and ex-vivo neutralization behavior of bluetongue virus serotype-16 recovered from apparently healthy goat. **Acta Tropica**. 194, 13-22. (NAAS-8.22; IF-2.509)

Book Chapter

Sagar A. Khulape and Kavita Bora (2018). Basic of primer design and sanger sequencing: In book by Division of Physiology and Climatology, ICAR-IVRI, Izatnagar during short training course CAFT (Veterinary Physiology) "Acclimatization and adaptation of high-altitude livestock in changing climatic scenario"pages 168-171.

Popular articles:

1. A Khulape, Kavita Bora and Manish Kumar (2018). Farm biosecurity for Foot and Mouth Disease. Sagar Agriculture World. Volume 4, Issue 9 September 2018, pages 38-40.

2. **Rajbhasha Hindi extension article:** खुरपका एवं मुँहपका रोग (एफएमडी) से फार्म में जैव सुरक्षा मनीष कुमार एंव सागर ए. खुलापे कार्यशाला जलवायु परिवर्तन के परिदृश्य में उत्तराखण्ड के किसानों की आजीविका सुरक्षा हेतु बकरी पालन आयोजकः भाकृअनुप–भारतीय पशुचिकित्सा अनुसंधान संस्थान मुक्तेश्वर परिसर दिनांकः 22 फरवरी 2019

12.2: Presentations in Conferences/ Symposia/ Seminars/ Other fora

1. Ranjan R, Biswal JK, Subramaniam S, Pattnaik B (2019). Understanding FMD virus ecology in cattle and buffalo under natural. *Annual convention cum conference of Indian Association of Veterinary Microbiologists, Immunologists and Specialists in Infectious Diseases on Scientific and Technological Innovations in Animal Health Care for better production and trade.* Department of Veterinary Microbiology, Bihar Veterinary College, Bihar Animal Sciences

University, Patna-800014, Bihar- Reg. to be held from February 04-06, 2019

2. Ranjan R, Biswal JK, Subramaniam S, Pattnaik B (2018). *Foot-and-Mouth Disease virus: Subclinical infection in cattle and buffalo. Veterinary Pathology Congress-2018.* Department of Veterinary Pathology, College of Veterinary Science and Animal Husbandry, Sardarkrushinagar Dantiwada AU, Sardarkrushinagar- 385 506, Banaskantha, Gujarat, India October 22-24th, 2018.
3. Dr. Khulape Sagar Ashok delivered lecture on 'Status of FMD in Wild life in India" for vets working in National park and sanctuaries during capsule course organized by Wild life division, IVRI, Izanagar on 19-11-2018
4. Dr. Smrutirekha Mallick delivered an oral presentation on "Evaluation of serum cortisol, acute phase proteins and HSP70 in cattle naturally infected with foot and mouth disease" in the XXVII Annual Conference of Society of Animal Physiologists of India (SAPI) from 27-28 November, 2018 at National Dairy Research Institute, Karnal

12.3 Awards:

1. Dr. Rajeev Ranjan has been awarded Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Science- 2017 for Animal Science by Shri Radha Mohan Singh, Union Agriculture and Farmers Welfare Minister on 16th July 2018 at New Delhi. He has worked on "Immunopathology and persistence of foot-and-mouth disease virus following natural infection in cattle and buffaloes in India". His report envisaged to determine the duration and site of persistence, genetic and antigenic variations of FMD virus under natural condition to provide the basis for effective control strategies.

Human Resource Developments

13

Training undergone by staff/Scientist

1. Dr M Rout participated in 21 days CAFT training programme on "Acclimatization and Adaptation of High Altitude Livestock in Changing Climatic Scenario", sponsored by ICAR, New Delhi and organized at CAFT in Veterinary Physiology, Division of Physiology and Climatology, ICAR-IVRI, Izatnagar – 243122, Uttar Pradesh from 1-21 June 2018.
2. Dr M Rout two days' training workshop for vigilance officers of ICAR Institutes conducted by ICAR-National Academy of Agricultural Research Management, Rajendra Nagar, Hyderabad - 500 030 during Vigilance Awareness Week – 2018 from 31.10.2018 to 01.11.2018
3. Dr R Ranjan participated in 21 days CAFT training programme on "Recent Approaches in Diagnostic Pathology and Oncology" in Department of Veterinary Pathology at College of Veterinary Science, GADVASU, Ludhiana, Punjab, 12th November to 02nd December, 2018.
4. Dr Saravanan S and Dr JK Biswal participated in three days training programme on Introduction to Analytical Veterinary Epidemiology jointly organized by ILRI-ICAR during 3-5, December, 2018 at ICAR-NIVEDI, Bengaluru, Karnataka

Training Organized/Conducted

1. During 2018-19, one training Programme on DIVA-ELISA was organized during 09-12, May 2018 in which scientists of AICRP on FMD participated.
2. Dr. B Pattnaik, Dr Rajeev Ranjan and Dr JK Biswal participated as a trainer in the on-line Foot-and-mouth Disease Investigation Training Course for India organized by EuFMD in January 2019. This course was conducted in partnership with ICAR-Directorate of FMD, India and EuFMD, FAO, Rome. This course is equivalent to 12 hours training time.

14 Extension Activities

1. Dr Sagar A Khulape, Mr Shyam Lal Tamta and Mr Manish Kumar participated in Kisan Mela organized by ICAR-Indian Veterinary Research Institute, Mukteswar on 28-02-2018
2. Dr JK Mohapatra and Dr Saravanan S along with other staff investigated FMD outbreak in Namdhari Seeds, Bidadi, Ramnagara taluk, Bengaluru on 16th May 2018 and advised farm authorities about vaccination, bio-security practises and discussed about possible reason for FMD outbreak
3. Dr JK Mohapatra and Dr Saravanan S along with other staff investigated FMD outbreak in NIANP farm 31st May and advised farm authorities about vaccination, bio-security practises and discussed about possible reason for FMD outbreak
4. Dr. Khulape Sagar Ashok organized training cum sensitization program on 'Preventive measures of PPR and FMD at field' at village -Sunkhiya (Nainital) in collaboration with IVRI Mukteshwar campus on 28-08-2018.
5. Dr Shyam S. Dahiya, Dr Sagar A Khulape and Mr Manish Kumar investigated FMD outbreak in Nayeli village on 02-08-2018 and advised farmers about vaccination, bio-security practises and discussed about possible reason for FMD outbreak
6. Dr Manoranjan Rout, Shyam S Dahiya and Mr Manish Kumar investigated FMD outbreak in Sona Farm Kashipur 15-09-2018 and advised farm authorities about vaccination, bio-security practises and discussed about possible reason for FMD outbreak
7. Dr Shyam S. Dahiya and Mr Manish Kumar participated in FMD awareness programme at village Jhankat, US Nagar organised by IVRI Mukteswar on 10-09-2018
8. Dr Shyam S. Dahiya, Dr Sagar A. Khulape and Mr Manish Kumar participated in Kisan Mela organized by VPKAS Almora at Hawalbagh on 27-09-2018
9. Dr Saravanan S along with other staff investigated FMD outbreak in Vinay Dairy Farm and surrounding villages, Dharward, Karnataka on 3rd November 2018 and advised farm authorities about vaccination, bio-security practises and discussed about possible reason for FMD outbreak
10. Dr JK Mohapatra and Dr Saravanan S along with other staff investigated FMD outbreak in Happy Dairy Farm, Tumakuru, Karnataka on 12th November 2018 and advised farm authorities about vaccination, bio-security practises and discussed about possible reason for FMD outbreak
11. Dr Saravanan S along with other staff investigated FMD outbreaks in different villages of Hasana district of Karnataka on 20th November 2018 and advised about vaccination, bio-security practices and discussed about possible reason for FMD outbreak
12. Dr Manoranjan Rout, Dr Shyam S. Dahiya and Mr Manish Kumar investigated FMD outbreak in village Gaj, Kapileshwar on 10-10-2018 and advised farmers about vaccination, bio-security practises and discussed about possible reason for FMD outbreak
13. Dr. Khulape Sagar Ashok organized training cum sensitization program on 'Prevention and control of PPR and FMD at field' at village-Hartola, Nainitalain collaboration with IVRI Mukteshwar campus on 07-12-2018.
14. Dr. Khulape Sagar Ashok organized method demonstration at Village- Sunkhari kala, Sitarganj under TSP program in collaboration with IVRI Mukteshwar campus on 15-02-2019.

Meeting/Conference/Symposium Attended by Staff/Scientist

15

1. Dr Saravanan S participated in Subject Matter Division meeting of Directors, PME In-charges, Administrative Officers and Account officer during 24- 25 April, 2018 at NASC, New Delhi
2. Dr Saravanan S and Dr JK Biswal participated in One day workshop on Disease Free Zone organized by DADF on 16th July 2018 at Hyderabad, Telangana
3. Dr Saravanan S participated in 2nd Brainstorming workshop on Development of pro-forma for ranking of ICAR institutes at NAAS, New Delhi on 28th July, 2018
4. Dr Saravanan S participated in FMD Brainstorming meeting at Central Institute for Research on Buffaloes, Hisar, Haryana during 14-15, September 2018 and delivered a expert lecture on Molecular epidemiology of FMD in India
5. Dr JK Biswal participated in FMD Brainstorming meeting at Central Institute for Research on Buffaloes, Hisar, Haryana during 14-15, September 2018 and delivered a expert lecture on Advanced Recombinant vaccines against Foot-and-mouth Disease
6. Dr R Ranjan participated in FMD Brainstorming meeting at Central Institute for Research on Buffaloes, Hisar, Haryana during 14-15, September 2018 and delivered a expert lecture on Subclinical Infection of Foot and Mouth Disease in Animals
7. Dr JK Mohapatra and Dr Saravanan S participated in the meeting to discuss about frequent outbreak in the state of Karnataka after 14th round of vaccination under FMDCP on 5th November 2018 under the chairmanship of hon'ble Minister, Animal Husbandry & Fisheries Department, Govt of Karnataka
8. Dr JK Biswal participated in 5TH Meeting of the SAARC-Laboratory Directors' Forum (SLDF) during 1st-3rd October 2018 at Bangkok, Thailand and presented on country updates on FMD.
9. Dr R Ranjan participated in National Symposium on "Recent Advances in Veterinary Pathology and Disease Diagnosis for Sustainable Livestock and Poultry Production" at Department of Veterinary Pathology, College of Veterinary Science and Animal Husbandry,Banaskantha, Gujarat, India, 22-24 October, 2018.
10. Dr. Smrutirekha Mallick participated in the XXVII Annual Conference of Society of Animal Physiologists of India (SAPI) from 27- 28 November, 2018 at National Dairy Research Institute, Karnal.
11. Dr JK Mohapatra and Dr Saravanan S participated in an interactive meeting convened by the Director, IAHVB, Bengaluru on 29-11-2018, which was addressed by prof. John Edwards, Former regional coordinator for the WHO/OIE South East Asia FMD Campaign and Coordinator ECTAD for UN FAO in China.
12. Dr R Ranjan participated in "III Workshop of Nodal Officers of ICAR Research Data Repository for Knowledge Management" at New Delhi, during 04-05 Dec 2018 organized by ICAR-IASRI.
13. Dr JK Mohapatra and Dr Saravanan S participated in the meeting to discuss about outbreak situation in the state of Karnataka on 25th January 2019 under the chairmanship of hon'ble Minister, Animal Husbandry & Fisheries Department, Govt of Karnataka
14. Dr Sagar A Kulape and Mr Manish Kumar participated in "State Level Workshop on

Foot and Mouth Disease Control Program of Uttrakhand" on 30 January 2019

15. Dr R Ranjan participated in annual convention cum conference of IAVMI on "Scientific and Technological Innovations in Animal Health Care for better production and trade" at Department of Veterinary Microbiology, Bihar Veterinary College, Bihar Animal Sciences University, Patna-800014, Bihar, 04-06th February 2019.

16. Dr R Ranjan participated in 47th Dairy Industry Conference 2019 on "Innovative Approaches for Enhancing Dairy Farmers income" organized by Indian Dairy Association, New Delhi in Collaboration with IDA (EZ), Kolkata & IDA, Bihar State Chapterd at Samrat Ashoka International Convention Kendra, Gandhi Maidan, Patna during 7-9th February 2019 and delivered a talk on "Combating FMD: A nemesis of dairy animal" during

17. Scientists of DFMD participated in 26th Annual Review Meeting of AICRP on FMD held at International Centre for FMD, Bhubaneswar, Odisha during 7-8, September, 2018

5TH Meeting of the SAARC-Laboratory Directors' Forum (SLDF) during 1-3 October 2018 at Bangkok, Thailand

Reports and Recommendations

16

Proceedings of 26th Annual Review Meeting (ARM) of All India Coordinated Research Project on Foot and Mouth Disease (AICRP on FMD) held at international Centre for FMD (ICFMD), DFMD, Bhubaneswar, during 7-8 September 2018.

The 26th Annual Review Meeting (ARM) of All India Coordinated Research Project on Foot and Mouth Disease (AICRP on FMD) was held on 7-8 September 2018 at the International Centre for Food and Mouth Disease (ICFMD), the constituent laboratory of ICAR – Directorate of Foot and Mouth Disease (ICAR- DFMD), Bhubaneswar, Odisha, under the **Chairmanship of Dr J. K. Jena, DDG** (Animal & Fishery Sciences), ICAR.

The following recommendations were made during the ARM

1. It is necessary to cover the stray animals (cattle) under FMDCP as these animals are also posing as a potential source of infection and carrier of the virus. (Action: AH Departments of State Govts, DADF and ICAR-DFMD)
2. All the animals covered under FMDCP should be ear tagged for their proper identification and tracking. (Action: AH Departments of State Govt., DADF)
3. The vaccination programme against FMD needs to be analysed by an appropriate committee with respect to schedule of vaccination, time and density of vaccination, serum sampling frame, quality and pay load of the vaccine and availability of the cold chain etc. (Action: DADF, ICAR-ASD and ICAR-DFMD)
4. The RDDLs and certain leading AICRP Centres will be strengthened depending on their capabilities, continuation of trained manpower and proficiency to carry out the Seromonitoring activities of FMDCP. (Action: ICAR-DFMD, DADF and ICAR-ASD)
5. The assessment of the economic impact of FMDCP to be made. (Action: DADF, ICAR-DFMD and ICAR-ASD)
6. The surveillance of FMD need to be further intensified in Maharashtra, Tamilnadu, Telangana. Andhra Pradesh, Puduchery and Punjab as there is no incidence of FMD in these states during the last 3-4 years.(Action: ICAR-DFMD and DADF, Govt. of India)

7. The cattle potency testing of the vaccine candidate strain of Serotype 'A' FMD virus undergoing at IVRI, Bangalore need to be completed and the IVRI-Bangalore centre to submit the final test report at the earliest. (Action: ICAR-ASD, ICAR-DFMD and DADF, Govt. of India)
8. DADF, GoI, may form a body to implement and evaluate the National FMD Control Programme and ensure serum sample collection from appropriate animals for monitoring of post-vaccinal immunity. A consultant may be engaged to monitor the FMD control programme(Action: DADF, ICAR-DFMD, ICAR-ASD)
9. All measures to be taken so that India can reach the stage 4 of the PCP for control of FMD. (Action: DADF, ICAR-DFMD, ICAR-ASD)
10. All the clinical materials collected from FMD cases to be sent to the International Centre for FMD (ICFMD) at Bhubaneswar, Odisha, instead of Mukteswar.
11. The Standard Operating Procedure (SOP) to be circulated again to all the AICRP Centres to follow during investigation of FMD outbreaks. (Action: ICAR-DFMD, DADF, ICAR-ASD)
12. The serum samples tested for the quantification of antibodies against FMDV by the AICRP on FMD, Guwahati Centre, using a commercial diagnostic kit showed erratic results. These serum samples to be retested at the National FMDCP seromonitoring Laboratory, Bengaluru. (Action: DFMD, AICRP on FMD, Guwahati and DADF)
13. In order to rule out the reported untoward reaction of the FMD vaccine, 10 calves may be vaccinated with double dose of FMD vaccine and kept on quarantine for 14 days for any adverse reaction, before use for mass vaccination. (Action: DADF, State AH Departments, ICAR-DFMD)
14. There should be quick response team/system in place in each AICRP on FMD Centres for investigation of FMD outbreaks / incidences at an earliest possible time. (Action: ICAR-DFMD, DADF and State AH Departments)
15. Each AICRP on FMD Centre will adopt a village in each district for close monitoring of FMD with 100 % vaccination of susceptible animals and collect serum samples for post-vaccination sero-monitoring. (Action: All AICRP Centres/ Collaborating Units, ICAR-DFMD, DADF and State AH Departments)
16. The AICRP on FMD Centres in Telengana, Andhra Pradesh, Tamilnadu, Puducherry, Punjab and Maharashtra should not receive any biological sample from other states for any laboratory testing for FMD as FMD in these states is under control. (Action: Concerned AICRP – FMD Centres in Telengana, AP, Tamilnadu, Puducherry, Punjab and Maharashtra, ICAR-DFMD, DADF and State AH Departments)
17. FMD vaccine bank need to be established in each state as a contingency plan to vaccinate animals in exigency at the time of FMD incidence / outbreak (Action: DADF, ICAR-DFMD and State AH Departments)
18. The areas having FMD outbreaks need to be reinvestigated / inspected after one year to assess the status of FMD in these areas. (Action: All AICRP Centres/ Units, DADF and State AH Departments)
19. FMD vaccination of the susceptible animals under FMDCP in a district / state to be completed within 30 days in every phase to achieve better response in each phase of vaccination. (Action: DADF and State AH Departments, ICAR-DFMD)
20. The performance of the AICRP on FMD Centre in Patna is not up to the mark. It should improve the epidemiological studies on FMD in Bihar during the next four months of time which will be evaluated by ICAR-DFMD and in case of unsatisfactory performance the centre will be shifted to the Bihar State AH Department. (Action: AICRP – FMD Centre, Patna ICAR-DFMD and ICAR-ASD)

21. The funds for Tribal Sub Plan (TSP) for the Mathura Centre will not be released as the funds released earlier could not be utilized. In order to address the crunch of laboratory space in the existing Dept. Of Vet. Microbiology, the university authorities of DUVASU, Mathura may be requested to release the AICRP on FMD building for use by the Centre. (Action: AICRP on FMD Centre, Mathura, ICAR-DFMD and ICAR-ASD)
22. The serum samples need to be collected from animals of 6 months to 1 year of age for testing of DIVA reactivity and animals above 2 years of age for monitoring of post-vaccinal immunity. (Action: All AICRP on FMD Centres/ Units, ICAR-DFMD, DADF and State AH Departments)
23. FMD surveillance and monitoring in small ruminants, pigs and captive animals need to be further strengthened. (Action: All AICRP Centres/ Units, ICAR-DFMD, DADF and ICAR-ASD)
24. The ICAR- NRC on Yak should collaborate with the AICRP on FMD Centre, Jammu for Epidemiological studies of FMD in Yaks available in the state of J&K (Action: ICAR–NRC on Yak, AICRP on FMD, Jammu, ICAR-DFMD, DADF, and ICAR-ASD)
25. The State AH Department of Meghalaya will send a letter of request from the competent authority for the establishment of an AICRP on FMD Centre in Meghalaya. (Action: State AH Department of Meghalaya, ICAR-DFMD, and ICAR-ASD)
26. The Director of ICAR-DFMD should be informed immediately for any incidence of FMD anywhere observed in the country for proper investigation in time to ascertain the epidemiological factors involved in the FMD incidence and immediate containment of virus spread. (Action: State AH Departments, All AICRP Centres/ Units, ICAR-DFMD, DADF, and ICAR-ASD)
27. ICAR-DFMD should conduct a technical audit of each ACRP on FMD centres/ units, and nature of serum samples being collected by the State AH Departments for Post-vaccination sero-monitoring. (Action: ICAR-DFMD, DADF, ICAR-ASD and State AH Departments)
28. Necessary action need to be initiated for digitalization of all the data and information accrued by AICRP on FMD from its inception. A document need to be prepared covering the achievements of the AICRP on FMD for the last 51 years. (Action: ICAR-DFMD, ICAR-ASD, All AICRP on FMD Centres/ Units)
29. Competent officials of the respective State AH Departments/ SAUs/ SVUs of the AICRP of FMD Centres to be invited in the next ARM of AICRP on FMD for better coordination of FMDCP activities in their states. (Action: DADF, ICAR-DFMD and ICAR-ASD)
30. The midterm review of the AICRP on FMD to be held within next 3 months before end of the year. The venue and dates to be finalized. (Action: ICAR-DFMD, ICAR-ASD)
31. Each AICRP on FMD Centre/ Unit should have one principal Investigator (PI) and at least one Co –PI. (Action: All AICRP on FMD Centres/ units, ICAR-DFMD, and ICAR-ASD)
32. The next (27th ARM) meeting of AICRP on FMD need to be held in time and the technical sessions will include presentation of 2-3 lead papers by the invited experts in FMD.

17 Personnel

Scientific

No.	Name of the staff	Designation	Discipline	Date of Joining ICAR	Date of Joining at DFMD
1	Dr. Bramhadev Pattnaik	Director	Veterinary Microbiology	04-08-1984	06-12-2006
2	Dr. Jajati K Mohapatra	Sr. Scientist	Veterinary Microbiology	27-06-2005	10-02-2006
3	Dr. Saravanan Subramaniam	Sr. Scientist	Veterinary Microbiology	08-01-2007	17-05-2007
4	Dr. Aditya Prasad Sahoo	Scientist (SS)	Animal Biotechnology	21-04-2009	10-07-2017
5	Dr. Manoranjan Rout	Scientist (SS)	Veterinary Pathology	04-11-2009	15-03-2010
6	Dr. Shyam Singh Dahiya	Scientist (SS)	Veterinary Microbiology	15-12-2009	10-07-2017
7	Dr. Rajeev Ranjan	Scientist (SS)	Veterinary Pathology	11-05-2010	18-09-2010
8	Dr. Jitendra K Biswal	Scientist (SS)	Animal Biochemistry	27-04-2011	02-09-2011
9	Dr. Khulape Sagar Ashok	Scientist	Animal Biotechnology	01-01-2015	10-04-2015
10	Dr. Smrutirekha Mallick	Scientist	Animal Physiology	01-07-2015	05-06-2017

Technical

Sl. No.	Name of the Staff	Designation	Date of Joining at ICAR	Date of Joining at DFMD
1	Shri Nayan Sanjeev	T-3 (Lab)	13-10-2005	13-10-2005
2	Shri S.L.Tamta	T-1 (Lab)	27-11-1982	19-04-2014

Administration and Accounts

Sl. No.	Name of the Staff	Designation	Date of Joining at ICAR	Date of Joining at DFMD
1	Shri Kumar Rishiraj	Adm. Officer	01-08-2016	17-12-2016
2	Shri Harish Chandra Saxena	AAO	-	03-11-2016
3	Shri Tara Kumar	Assistant/AAO	17-08-1985	15-04-2013
4	Shri R.N.Sahoo	UDC	31-10-1996	03-05-2012
5	Shri Ravi Chaudhary	Junior Stenographer	06-09-2014	06-09-2014

Shri Kumar Rishiraj resigned on 29-12-2018

Shri Harish Chandra Saxena retired on 31-03-2018

Shri Tara Kumar promoted as AAO on 16-04-2018

Photo Gallery

Vigilance Awareness Week 2018






Vigilance awareness activities conducted during "Vigilance Awareness Week 2018" at ICAR-Directorate of FMD, Mukteswar, Government Inter College Mukteswar, Government Higher Secondary School Reetha, Government Inter College Gehna, Government Girls Inter College Bhatelia, Government Inter College Kashiyalekh and Sarawati Sishu Vidya Mandir, Gonguwachoud

Hindi Pakhwara


Swachchh Bharat Abhiyan






ICAR- DFMD-ICFMD organised Swachh Bharat Abhiyan progammmes

Kisan Mela

ICAR-DFMD, Mukteswar participated in Kisan Mela organized by VPKAS Almora at Hawalbagh

Dignitaries who visited ICAR-DFMD

Visit of Prof. M.P. Yadav & Dr. G.C. Mohanty to ICAR-ICFMD on 20.12.2018

Visit of OIE Expert team to ICAR-ICFMD on 27.06.2018

Visit of Secy, ICAR & Dir (Finance) to ICAR-ICFMD on 23.06.2018

Visit of Spl. Secy, DARE & Secretary, ICAR to ICAR-ICFMD on 27.12.2018

ICAR-DFMD, Mukteswar organized a programme on "अटल बिहारी वाजपेयी की कविताएं" to give fitting tribute on the first monthly death anniversary (16th September 2018) of Bharat Ratna Late "Sh. Atal Bihari Vajpayee Ji"

ICAR-DFMD, Mukteswar organized FMD awareness camp, collaboration with IVRI, Mukteswar at Village Jhankat, Udham Singh Nagar

N O T E

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