

**MAIN LABORATORY BUILDING (MLB), ICAR-ICFMD**



# **ANNUAL REPORT 2017-18**



**ICAR-DIRECTORATE OF FOOT AND MOUTH DISEASE**  
**MUKTESWAR 263 138 (INDIA)**



# **ANNUAL REPORT**

## **2017-18**



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



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# Introduction and Executive Summary

Foot and Mouth Disease (FMD) is one of the most contagious transboundary animal diseases (TADs) in the world, caused by multiple antigenic types of FMD virus, posing constant threat to food security locally and globally. Spread of the disease occurs through contaminated air, water, feed, fomites, livestock movement and trade etc.

As of today, FMD is still wide spread in the world including Africa, West Eurasia, Asia and Middle East. About 70 countries are free from FMD and are always under threat of virus incursion from endemic countries through different ways and means. The burden of FMD on developing countries is usually underestimated. The disease threatens livelihood security. With a fast moving infection, surveillance is essential and building up national and regional epidemio-surveillance capacities is a priority (FAO-FMD, May 2018). The direct economic impact of FMD is attributed to drop in milk production (upto 80%), abortions, and death of young calves. The indirect adverse effect includes loss of draught power in bovine for various works including cultivation and transportation, the cost of treatment and implementation of FMD control programme, and trade embargo by FMD free countries (FAO-FMD, May 2018). FMD outbreaks in countries where the disease was earlier eradicated can cause loss of ~1.5bn USD /year (FAO-FMD,

May 2018). Similarly, the cost burden in endemic regions is approximately is more than 6.5bn USD/year (FAO-FMD, May 2018). In India, annual direct loss is estimated at Rs. 20,000 (about 3.5bn USD) crore. Indirect loss due to trade barrier could be much more.

Controlling FMD and reducing its impact would have a hugely positive economic impact on both FMD endemic and FMD-free countries (FAO-FMD, May 2018). The global FMD control strategy includes; (1) disease detection and reporting incidences/outbreaks in real-time, (2) manage risks in virus spread, and (3) prevent escape of virus from laboratories. India has a system in place to diagnose outbreaks in real-time since last more than four decades, and with the establishment of the state-of-the-art high containment (BSL-3Ag) laboratory facility named as International Centre for FMD (ICFMD) in 2017, it completes the mandatory strategy/requirement to achieve control and eradication of FMD in the country. Majority of the FMD endemic countries including India follow Progressive Control Pathway (PCP) of FAO, a 5-stage approach from step 0 to step 5, and addition of the ICFMD facility by the ICAR will meet the critical requirement when India enters stage 4 of the PCP.



Inauguration of ICAR-ICFMD by the Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India ShriRadha Mohan Singh on 01.04.2017 at Arugul, Jatni, Bhubaneswar. Main laboratory building of high containment laboratory facility (BSL3Ag).

International Centre for Foot-and-mouth disease (ICFMD) with state-of-the-art high containment laboratory facility (BSL3Ag) was inaugurated by the Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India on 01.04.2017 at Arugul, Jatni, Bhubaneswar to cater the need of the Country and SAARC member countries for safe handling of viruses, that is essential for Control and eradication of FMD.

The ICAR-DFMD and its AICRP component (AICRP for epidemiological studies on FMD) 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&F, Govt. of India since 2003-04.

In India, three serotypes (O, A and Asia1) of FMD virus (FMDV) are prevalent. Serotype O is the most prevalent one followed by serotype Asia1 and A. During 2016-17, all the FMD incidences in the country were caused by serotype O. Regular and intensive surveillance has yielded valuable epidemiological data to prove decline in occurrence of FMD in vaccinated populations. As a result of this, India is in the Stage 3 (recognised by OIE) of FAO's Progressive Control Pathway (PCP) for control of FMD, where disease is under control in areas under FMDCP.

During the year 2017-18 (Tables 1 & 2), a total 149 incidences of FMD were recorded in the country. Almost 60% of the incidences were in the southern region of the country, and 92% of the incidences were in the state of Karnataka. During the period, six states (Andhra Pradesh, Telangana state, Maharashtra, Punjab, Madhya Pradesh and Arunachal Pradesh) and two UTs (Puducherry and A&N Islands) had no incidence of FMD. There has been reduction in disease incidences in eastern and north eastern regions. Two fold increase in FMD incidences was recorded in southern, northern and western regions. Most of the incidences were sporadic in nature involving only a few animals with very mild clinical lesions. This is the 15<sup>th</sup> year of FMDCP in the country, that has boosted herd immunity resulting in progressive clearance of

the virus from regularly vaccinated population, as revealed by DIVA values described later.

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

Year	South	North	Central	West	East	North East	Total
2013-14	228	32	35	27	103	40	472
2014-15	10	4	10	3	25	24	76
2015-16	89	18	26	23	44	52	252
2016-17	49	11	05	06	22	57	150
2017-18	101	17	-	10	-	21	149

The serotype O continued to be most predominant one and was responsible for 98% of the incidences recorded during 2017-18. The serotype Asia1 was recorded in the states of Rajasthan and Kerala only. Though regular prevalence of serotype Asia1 has been witnessed in the western region including Rajasthan, the serotype appeared after four years of absence in the southern region, which might be considered as an epidemiologically significant event. This situation is under watch.

**Table 2:** Year wise outbreaks/incidences of FMD and virus serotypes involved during last 15 years.

Year	No. Of Outbreaks/ incidences	O	A	Asia1
2002-03	1541	1343	143	55
2003-04*	1911	1515	230	166
2005-06	1486	1238	131	117
2006-07	781	491	84	206
2007-08	879	753	67	56
2008-09	245	200	21	24
2009-10	600	560	24	16
2010-11	176	150	10	16
2011-12	347	246	16	85
2012-13	333	265	16	52
2013-14	472	454	08	10
2014-15	76	75	0	01
2015-16	252	244	06	02
2016-17	150	150	0	0
2017-18	149	146	0	03

\*Beginning of the FMD Control Program

It may be seen that in the 3<sup>rd</sup> year of the FMDCP (2006-07), the number of FMD outbreaks/incidences came down by almost 60% (781 from 1911), and in 2008-09 the number of incidences came down to 245, further ~70% drop in the incidences of the disease. This speaks about positive

effect of regular vaccination under the FMD control program. There were some fluctuations/deviations later due to unavoidable reasons like delay in vaccination. However, again the laurel was achieved during 2014-15, when there were only 76 incidences of FMD (96% drop in occurrence since 2003-04), mostly caused by the serotype O FMD virus. The fluctuation during 2015-18 is attributed to expansion of the FMDCP since 2016 to cover the entire country. Again we are in the recovery mode with only about 150 incidences each during 2016-2018 (about 92% drop in occurrence since 2003-04). This progressive drop in the incidences of FMD is attributed to success of the FMDCP that has boosted herd immunity. Since last more than 5 years, serotype O FMDV has been dominating over the serotypes A and Asia1 (Table 2).

Incidences FMD were recorded throughout the year. Maximum incidences of FMD were recorded during the months of February and March almost like the previous year.

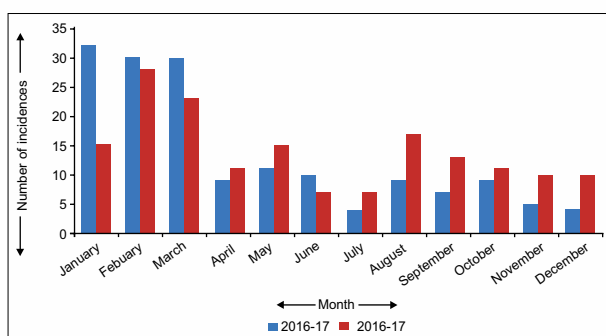


Fig. 1: Monthly incidence of FMD (2016-18)

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 294 field virus isolates (O-213, A-43 and Asia 1-38) were antigenically characterized during 2012-2017. The field situation suggested emergence of antigenically divergent strains in serotype A, while majority of isolates in serotype O and Asia1 were found to be antigenically related to their respective vaccine strains. To circumvent emergence of antigenically divergent VP3<sup>59</sup> deletion group strains in 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. During the year, 50 serotype FMDV field isolates of serotype O were characterized antigenically using Bovine Vaccinate Serum (BVS) against in-use vaccine strain INDR2/1975. The vaccine strain demonstrated optimal antigenic coverage with 88% of the isolates showing antigenic match.

Phylogenetic analysis based on P1/VP1 coding region was carried out to assess genetic variations/mutations/recombination, inter-strain relationships and track movement of the virus. Capsid coding region (P1/VP1) sequences of 463 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 2017. 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 121 serotype O virus isolates were added to the repository during the reported period (Table 7). At present the National FMD virus Repository holds a total of 2065 isolates (O-1482, A-325, C-15 and Asia1-366).

Since launch of the vaccination based FMD control program in 2003-04, the ICAR-DFMD has been providing all necessary laboratory and scientific backup to the program. Under this, the ICAR-DFMD provides 03 important companion diagnostics (LPBE/SPCE, NSP-DIVA, and virus diagnosis) to evaluate the effect of FMD vaccination in cattle and buffalo.

Under FMDCP seromonitoring to assess the effectiveness of vaccination under the program,

a total of 1,59,790 serum samples from the states of Punjab, Telangana State, Andhra Pradesh, Maharashtra, Karnataka, Tamilnadu, Kerala, Gujarat, Uttarakhand, Chhattisgarh, Rajasthan, Goa and Puducherry were received and tested using SPCE (4,80,000 tests). Till today, a total of 10,02,437 serum samples collected under FMDCP have been tested (>30 lakh tests) for post-vaccination protective antibody response in cattle and buffalo. The best success story of FMDCP is Delhi, followed by Telangana State (TS), Punjab, Andhra Pradesh, Gujarat and Maharashtra. The other states have to improve. Delhi is the only ideal state under FMDCP with a strong herd immunity of 69-81%, post vaccination sero-conversion of 92%, and DIVA positivity of < 2%.

Under National FMD serosurveillance; 42,010 bovine serum samples collected at random from various parts of the country were tested in r3AB3 NSP-ELISA (DIVA) for assessing the prevalence of NSP-antibody (NSP-Ab) positive animals, which is an indicator of FMD virus exposure regardless of vaccination status. The test revealed overall seropositivity in ~ 21.2% samples/animals, which is comparatively lesser than the previous year's average (Table 3). During 2008-2018, a total of 4,44,616 serum samples have been tested for DIVA.

**Table 3: DIVA positivity/reactivity over the years in bovine of India**

Year	Number of Incidences	% DIVA reactors
2002-03	2476	** In 1995, 91% in cattle, 89% in sheep and 59% in goat
2003-04*	1804	
2004-05	2894	
2005-06	1486	
2006-07	781	
2007-08	876	
2008-09	245	27.94
2009-10	599	27.90
2010-11	176	26.87
2011-12	347	26.09
2012-13	331	26.41
2013-14	472	29.20
2014-15	76	23.41
2015-16	252	22.54
2016-17	150	22.0
2017-18	149	21.2

\* Beginning of the FMD Control Program

\*\* During 1995, 91% of bovine serum samples, 89% of ovine serum samples and 59% of caprine serum samples were DIVA positive indicating higher circulation of virus at that time. This DIVA detected antibodies to NSP-3D polymerase (VIA; virus-infection-associated antigen). With the implementation of FMDCP since 2003-04, DIVA positivity in bovine has dropped to 21.2 % in 2017-18, so as in ovine and caprine (~18%). Gradual clearance of virus has resulted in gradual decrease in DIVA positivity in the country and concurrent reduction in incidences of FMD. This speaks of success of FMDCP and the effect of regular vaccination.

Under the FMDCP, small ruminants (sheep and goat) are not covered under vaccination. However, with gradual decrease in DIVA positive bovine (now ~21%), there is concurrent reduction in DIVA positive small ruminants also (~18%). The proportion of small ruminants positive for DIVA is less than that of bovine. This information/data generated using DIVA test, supports our earlier observation that small ruminants do not pose threat (for FMD) to cattle and buffalo; but is the other way. The data also proves that limiting virus circulation (i.e. virus clearance from herd) in bovine, effected by regular vaccination, has automatically limited FMD virus circulation/infection in sheep and goat resulting in drop in DIVA reactivity.

Information on DIVA reactivity obtained year after year has revealed a direct relationship between DIVA positivity and number of incidences of FMD. The states under FMDCP vary in DIVA positivity/reactivity. Many states have higher DIVA positivity than current country average of 21.2%. Available data reveals that there are every chance of occurrence/recurrence of FMD when DIVA positivity in a herd/area crosses 25% mark.

Current DIVA positivity/reactivity (in %) in different states vary due to differential incidence of FMD, and differential antibody response post vaccination. DIVA positivity, in order of merit, is Delhi (<2%), Telangana (<2%), Maharashtra (<6%), Punjab (<10%), Kerala (17.5%), Uttar Pradesh (20%), Gujarat (21%), Andhra Pradesh (22.5%), Tamil Nadu (25%), Rajasthan (28%), Karnataka

(30%) and Haryana (32%). This differential DIVA positivity is due to the different level of sero-conversion following vaccination, level of herd immunity, and number of incidences of FMD. The best possible scenario of FMD control is in Delhi and Telangana.

### Success Indicators of FMDCP are described below:

1. After 14 years, 92% drop in occurrence of FMD in 2007-08 compared to 2003-04.
2. After 3 years of FMDCP, in 2006-07, the incidence had dropped by about 60% compared to 2003-04.
3. After 5 years of FMDCP, in 2008-09, there was about 70% drop in the incidence compared to 2006-07.
4. 74% drop in DIVA positivity in bovines in 2017-18 from the baseline data of 1995. By 2008-09, DIVA positivity had dropped to about 28%, and now in 2017-18, it is 21.2%.
5. More is the DIVA positivity, more is the occurrence of FMD, and vice versa.
6. The best success story of FMDCP is in Delhi, followed by Telengana State, Punjab, Andhra Pradesh, Gujarat and Maharashtra.
7. Delhi is the ideal state with a strong herd immunity of 69-81%, post vaccination seroconversion of 92% and DIVA positivity of <2%.

During the year 2017-18, new research projects were undertaken in the cutting-edge areas of FMD virus research by the scientists of the institute. A study was carried out to assess the suitability of uncleaved 2A-peptide of FMDV to present foreign antigenic epitopes on the surface of FMD virion which could be used as a novel diagnostic or prophylactic antigen. A negative marker virus and its companion ELISA were developed for FMD serotype Asia1 that provided the basis to devise a marker vaccine that is subsequently required as the country reaches Stage 4 of PCP. The details are presented later in the report.

FMDV infection parameters were examined

for calves born to FMD convalescent cows, asymptomatic cows from infected herds, and cows from the farm with no history of FMD. The within-herd FMD transmission dynamics during the acute-phase and duration of FMDV persistence and seroprevalence of FMD under natural conditions in an endemic setting was studied. The transmission co-efficient and basic reproductive numbers were estimated as 16.2-18.4 and 67-88, respectively. The details are presented later in the report.

I am happy to share that ICAR-DFMD is a member of the Global FAO/OIE Network of FMD Reference Laboratories that constitutes of ten other FMD laboratories in the world. The institute also functions as the FAO-FMD Reference Center and SAARC Regional Leading Diagnostic Laboratory for FMD. The institute is also now a member of GFRA (Global FMD Research Alliance). The 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 staffs of the institute for their sincere efforts and contribution in accomplishing the tasks assigned to the institute. We are indebted to the scientific and administrative support of Dr. T. Mohapatra, Hon'ble Secretary, DARE & Director General, ICAR, Shri Chhabilendra Roul, Special Secretary DARE & Secretary, ICAR, AS & FA, DARE/ICAR and Dr. J.K. Jena, Dy Director General (AS), as well as Dr. Ashok Kumar, Asst Director General (AH) and Dr. Jyoti Misri, Principal Scientist (AH) for their continued support. Also, the help and support extended by Dr. Vineet Bhasin, Principal Scientist (AGB) and Dr. Ranjan Gupta, Principal Scientist (ANP) is acknowledged.

# Vision, Mission, Mandate, Objectives and Technical Programme

## 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 seroconversion. 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.

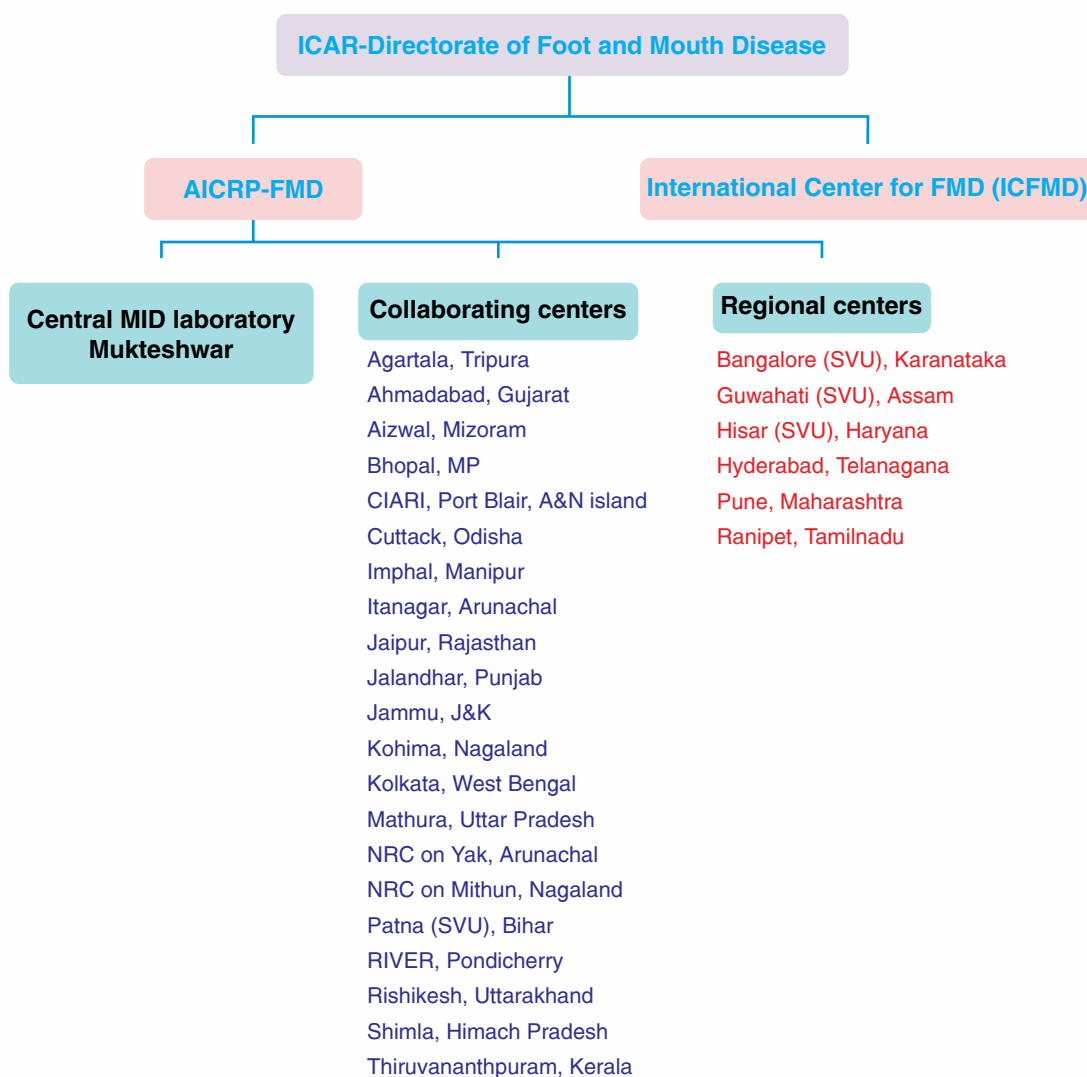
## Technical Programme

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.

# 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.



**Table 4.1** FMD incidences recorded and diagnosed during 2017-18 and virus serotype(s) involved

States	Reporting AICRP Centre/Unit	No. of. FMD cases/ outbreaks	No. of. Samples tested	Virus Serotypes		
				O	A	Asia1
Southern Region						
Andhra Pradesh	Hyderabad	No incidence				
Telangana	Hyderabad	No incidence				
Tamil Nadu	Ranipet	01	04	01(02)		
Karnataka	Bangalore	93	211	93(148)		
Kerala	Thiruvanthapuram	07	19	06(06)		01(01)
Puducherry	Puducherry	No incidence				
Andaman & Nicobar	Port Blair	No incidence				
Total		101	234	100(156)		01(01)
Northern Region						
Haryana	Hisar	05	42	05(27)		
Himachal Pradesh	Shimla	02	06	02(06)		
Jammu & Kashmir	Jammu	04	18	04(09)		
Punjab	Jalandhar	No incidence				
Uttar Pradesh	Mathura	08*	Serotype identification was not done			
Uttarakhand	DFMD	06	45	06(26)		
Total		25	111	17(68)		
Central Region						
Madhya Pradesh	Bhopal	No incidence				
Western Region						
Gujarat	Ahmadabad	05	17	05(17)		
Maharashtra	Pune	No incidence				
Rajasthan	Jaipur	05	23	03(04)	-	02(02)
Total		10	40	08(21)		02(02)
Eastern Region						
Odisha	Cuttack	03*	Serotype identification was not done			
Bihar	Patna	01*	Serotype identification was not done			
West Bengal	Kolkata	08*	Serotype identification was not done			
Total		12				

States	Reporting AICRP Centre/Unit	No. of. FMD cases/ outbreaks	No. of. Samples tested	Virus Serotypes		
				O	A	Asia 1
North Eastern Region						
Assam	Guwahati	12	111	12(101)		
Meghalaya		01	01	01(01)		
Nagaland	Kohima	04	04	04(04)		
Mizoram	Aizwal	01	05	01(05)		
Manipur	Imphal	02	12	02(06)		
Nagaland	NRC Mithun	01	02	01(02)		
Arunachal	Itanagar	No incidence				
Total		21	135	21(119)		
Grand Total		169	520	146(364)	-	03(03)

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

\* No reported case could be confirmed in the laboratory.

## 4.1 Southern Region

Southern region comprises of five states (Tamil Nadu, 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 states of Andhra Pradesh and Telengana, Puducherry (UT) and Andaman and Nicobar Island (UT).

**Tamilnadu:** One incidence of FMD due to serotype O was recorded in the month of December, 2017 in Thiruvallur district. The incidence was recorded in cattle.

**Karnataka:** During the year, 93 FMD incidences were reported in the state. In 2016-17, the DIVA positivity of the state was about 31%. All of them were caused by serotype O. The incidences were widespread and reported from the districts of Bengaluru Urban (11), Bengaluru Rural (17), Chikballapura (10), Kolar (15), Tumkur (09), Ramnagara (14), Mandya (02), Chikmangalore (09), Gulbarga (01), Hassan (02), Uttar Kanada (01) and Dakhsina Kanada (02). The incidences

occurred in the month of August 2017(14), March 2017(12), September 2017(11), October 2017(10), May 2017(9), April 2017(8), November 2017(8), February 2018(7), December 2017(5), July 2017 (5), January 2018(3) and June 2017(1). Majority of the incidences were epidemiologically linked, appears to be extension from a single incidence. The incidences were recorded in cattle and pig.

**Kerala:** A total of 7 incidences of FMD were recorded in the state affecting only cattle. FMDV serotype O caused six incidences and the remaining was due to serotype Asia1 in Kottayam district. The disease was recorded in the districts of Alappuzha (01), Thrissur (01), Ernakulam (02), Kannur (01), Kottayam (01) and Wayanad (01). The incidences were recorded in the months of June 2017 (01), July 2017 (01), August 2017 (02), December 2017 (02) and January 2018 (01). The serotype Asia1 appeared after four years of absence in the southern region (Kottayam), which might be considered as epidemiologically significant event. This has been possibly facilitated by movement of dairy animals from western region.

## 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. **There is no incidence of FMD in MP.** The region shares no international border. The entire central region is covered under FMDCP.

### 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. **No FMD was reported during the period in the state of Maharashtra.**

**Gujarat:** During the year, five incidences of FMD were recorded, and caused by serotype O. The incidences were recorded in the districts of Kheda (04) in the month of January 2018 and Gandhinagar (01) in the month of March 2018. The incidences were recorded in cattle and buffalo.

**Rajasthan:** Five incidences of FMD were recorded during the period. Three incidences were caused by serotype O in the districts of Udaipur (02) in November 2017 and Jaipur (01) in January 2018. Disease due to **serotype Asia1** was recorded in Jaipur (02) in the month of January 2018.

### 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. **No FMD was reported during the period in the state of Punjab.**

**Haryana:** During the year, 5 incidences of FMD were recorded in the state and all of them were caused by serotype O. Two incidences were recorded in the month of February 2018 and one incidence each in the months of March 2017, August 2017 and September 2017. The incidences were reported from the districts of Hisar (03), Sirsa (01) and Fatehabad (01). The species affected includes cattle, buffalo and pig.

**Himachal Pradesh:** Two incidences were recorded in the state caused by FMDV serotype O. The incidences were recorded in the months of May 2017 and June 2017 in the districts of Mandi and Shimla. The disease occurred in bovine species.

**Uttar Pradesh:** Series of eight suspected incidences of FMD were reported during January to March 2018 in the districts of Mathura and Aligarh. But serotype identification could not be performed, due to late reporting of the disease.

**Uttarakhand:** Six incidences of FMD was recorded, and caused by serotype O. The disease was reported from Almora (02), Tehri Garwal (02), Nainital (01) and Udham Singh Nagar (01) in the month of February 2017.

**Jammu & Kashmir:** During the period, four incidences were recorded in the district of Jammu caused by serotype O. The incidences were recorded in the months of February 2018 (02) and March 2018 (02) in bovine species.

### 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:** Three suspected incidences of FMD were recorded in the state in the month of April, May and December 2017. The incidences were reported in the districts of Nayagarh, Kandhamal and Dhenkanal. Serotype identification could not be done, due to late reporting of the disease.

**West Bengal:** Eight suspected incidences of FMD were recorded during the months January and February 2018. The incidences were recorded in North 24 Paraganas (03), Howrah (02), South 24 Paraganas (01), Hooghly (01) and Bankura (01). The disease occurred in cattle and buffalo. Serotype identification could not be done, due to delayed reporting of the incidence.

**Bihar:** One suspected incidences of FMD was recorded in Patna district. Serotype identification could not be done, as the incidence was reported late.



## 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.**

**Meghalaya:** One incidence of FMD caused by serotype O was recorded in cattle in the district of Ri-Bhoi in the month of March 2017.

**Nagaland:** During the year, four incidences of FMD were recorded in the state caused by serotype O. The incidences were recorded in the districts of Kohima (02) and Peren (02) in the months of March (02) and April (02), 2017.

**Assam:** Twelve incidences of FMD were recorded in the state during the period. Serotype O accounted for all the incidences that were recorded in cattle. The incidences were occurred throughout the year in the months of March 2017 (01), May 2017 (04), June 2017 (02), July 2017 (01), October 2017 (01), December 2017 (01) and January 2018 (02). The disease occurred in the districts of Kamrup (07), Barpeta (03), North Lakhimpur (01) and Darrang (01).

**Manipur:** During the year, 2 incidences of FMD caused by serotype O were recorded in cattle, buffalo and goat. One incidence each was recorded in the districts of Kangpokpi and Tamenglong in the month of June 2017.

**Mizoram:** One sporadic incidence was recorded in the state caused by FMDV serotype O. The incidence was recorded in the months of March 2017 in the district of Aizawl affecting only cattle.

**Nagaland:** One incidence in **Mithun** was recorded in the state caused by FMDV serotype O. The incidence was recorded in the month of February 2018 in the district of Dimapur.

## 4.7 Molecular epidemiology FMD

### 4.7.1: FMDV Serotype O

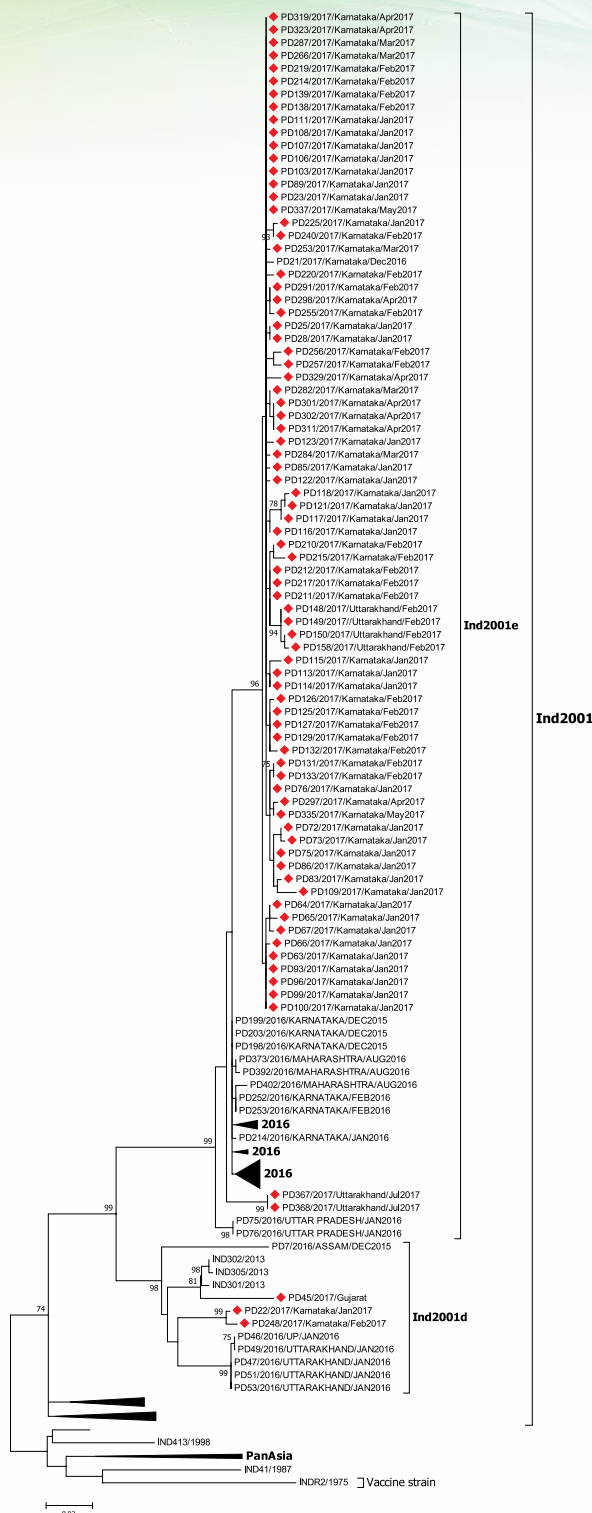
During 2017-18, a total of 84 serotype O FMDV field isolates were subjected to complete 1D/VP1 region sequence analysis. Maximum

Likelihood (ML) tree was reconstructed using MEGA 6.06 software package. In the ML tree all the 84 isolates grouped within O/ME-SA/Ind2001 lineage signifying its exclusive dominance in the field in recent times (Fig.4.1). The lineage, which re-emerged in the year 2008, continued its supremacy in the field by replacing the then prevalent O/ME-SA/PanAsia lineage. Since its actual identification in the year 1997, the lineage has diversified globally in to at least five sub-lineages (Ind2001a, b, c, d and e). **The emergence and prevalence of sub-lineage O/ME-SA/Ind2001e was recorded during 2016-17;** during this period almost 89% of the serotype O FMDV isolates grouped distantly from sub-lineage Ind2001d that caused several FMD incidences during the year 2013 in the southern region. The sub-lineage then designated as Ind2001e had a mean nucleotide divergence of 7.5% from the Ind2001d isolates.

Present analysis indicates that **sub-lineage Ind2001d is in the brink of extinction** as 81 of 84 isolates characterized during 2017-18 clustered within **sub-lineage Ind2001e**. Only three isolates; two from the state of Karnataka and one from the state of Gujarat grouped within Ind2001d sub-lineage. **The isolates of Ind2001e collected during 2017 are highly homogeneous** with only 1.4 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 Ind2001 isolates collected during 2017 differed from currently used vaccine strain INDR2/1975 by 11.6 to 14.8% at nucleotide level at 1D genomic region nucleotide sequence. Surprisingly, two isolates collected from the states of Uttarakhand in the month of July 2017 maintained a considerable phylogenetic distance from four isolates collected during February from the same state indicating **multiple independent incursion of virus into the state.**

### 4.7.2: 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



**Fig. 4.1:** Maximum Likelihood phylogenetic tree at VP1 coding region of Indian serotype O FMD virus isolates during 2017-18. The tree shows complete dominance O/ME-SA/Ind2001e sub-lineage in India during the period. Isolates sequenced during 2017-18 are indicated (red rhombus).

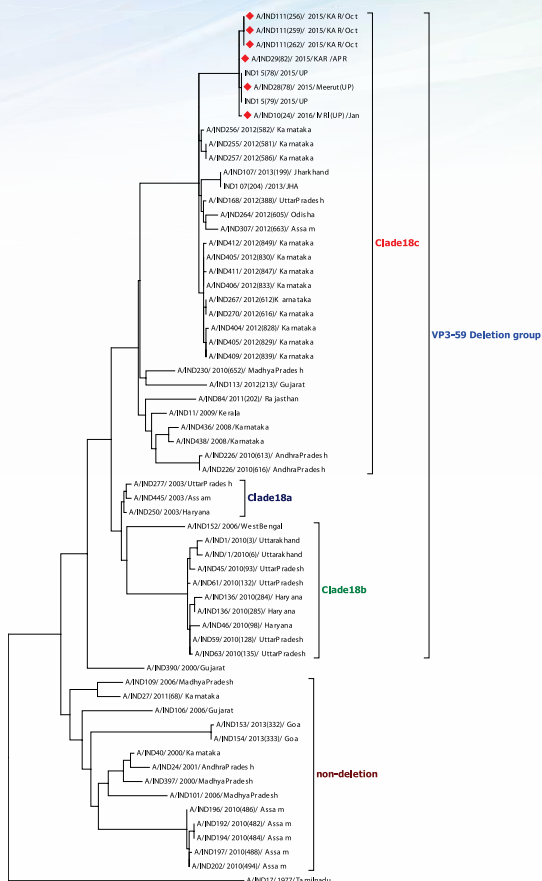
circulation of four genotypes {showing more than 15% nucleotide (nt) divergence among them at 1D

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 59<sup>th</sup> position of VP3 (VP3<sup>59</sup>-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<sup>59</sup> 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<sup>59</sup> deletion could be identified during 2015-16 in support of the anticipated exclusive dominance of the VP3<sup>59</sup> deletion group. For the last two year, no incidence of FMDV serotype A is recorded in the country.

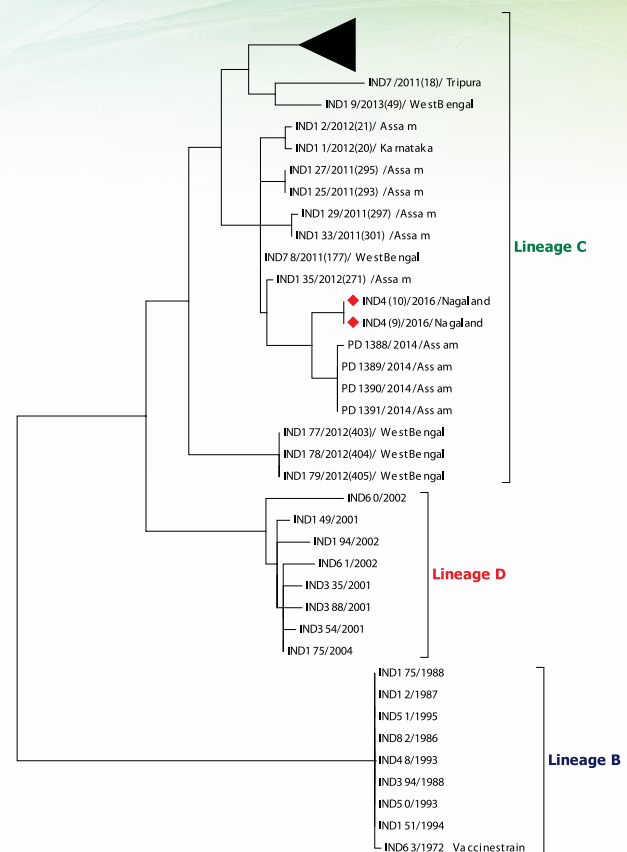
### 4.7.3: FMDV Serotype Asia1

Previous studies on 1D/VP1 gene based phylogeny demarcated Indian serotype Asia1 field isolates into 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 2015-16 was found to cluster within lineage C indicating its supremacy in the field since the year



**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<sup>59</sup> deletion group.



**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.

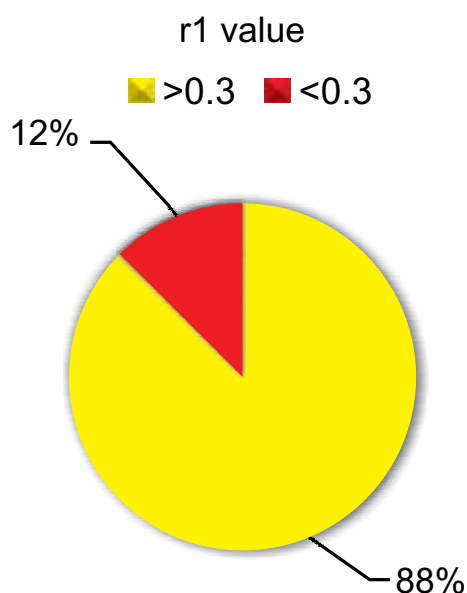
2005 (Fig. 4.3). The incidence was recorded during the month of December 2015, and the isolates were found to cluster closely with the isolates from Assam. During 2016-17, no incidence of FMDV serotype Asia1 was recorded in the country. Three

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.

# 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). A total of 50 virus isolates were subjected to vaccine matching exercise using bovine vaccinate serum during 2017-18. From the result, it can be seen that 88% of the isolates showed an  $r_1$  value of  $>0.3$  with currently used vaccine strain INDR2/1975, which indicates optimal antigenic coverage by the in-use vaccine strain.



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

## 5.2 FMDV serotypes A and Asia1

The field situation suggested emergence of antigenically divergent strains in serotype A, while majority of isolates in Asia1 were found to be antigenically related to the in-use vaccine strain, IND63/1972. With the recent emergence of antigenically divergent VP3<sup>59</sup> 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 is under progress. 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.

## 6.1 Newer diagnostic methods

### 6.1.1 Displaying foreign epitope within the uncleaved 2A-peptide of FMDV

FMDV capsid precursor protein P1-2A is cleaved by viral-encoded 3C protease (3Cpro) to generate VP0, VP3, VP1 and 2A proteins. It was reported earlier that substitution of a single amino acid residue within the 2A peptide sequence (L2P) blocked the 3Cpro mediated VP1/2A cleavage and produced 'self-tagged' FMDV particles containing uncleaved 2A-peptide. To determine whether the uncleaved 2A-peptide can function as a target structure to harbour and display exogenous epitope on FMDV particles, a full-length FMDV cDNA clone containing a hemagglutinin (HA)-tag within the uncleaved 2A-peptide sequence was constructed. Subsequently, chimeric marker FMDV, displaying a HA-tag on the viral surface was rescued through reverse genetics approach. The 2A-HA epitope tag-inserted recombinant chimeric FMDV serotype O was genetically stable through up to ten serial passages in cell culture and exhibited growth properties similar to the parental virus. Furthermore the surface displayed HA-epitope tag was able to react with anti-HA antibodies as determined by various immuno-assays (Fig. 6.1). The results

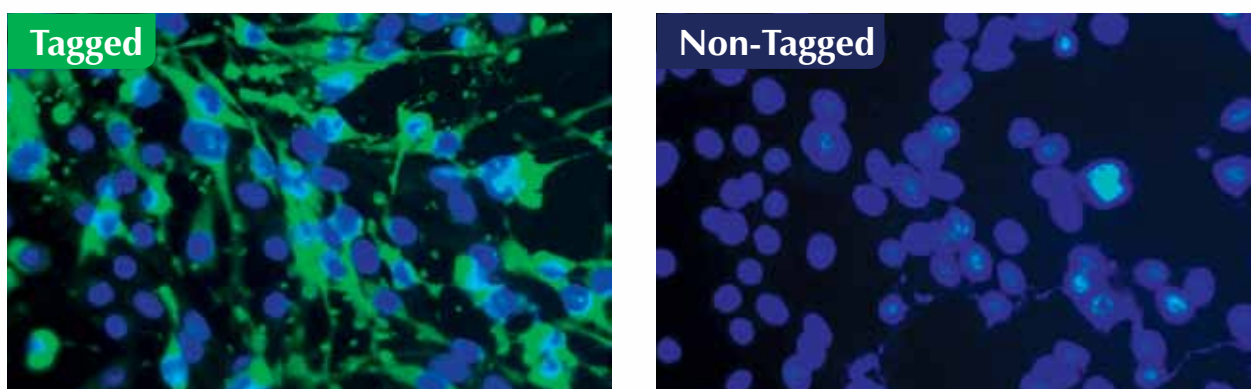
suggest that the uncleaved 2A-peptide of FMDV is suitable to present foreign antigenic epitopes on the surface of FMD virion and the chimeric FMDV particles could be used as a novel diagnostic or prophylactic antigen.

## 6.2 Designer virus construction for advantage

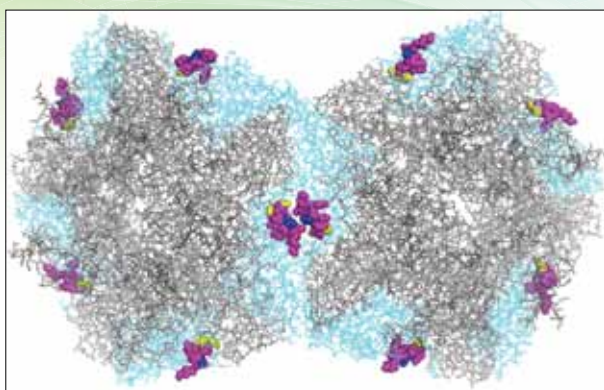
### 6.2.1 Evaluation of thermostable foot-and-mouth disease virus strain for its potential as a vaccine candidate

FMD virus serotype O vaccine strain with **enhanced thermo-stability** was constructed using reverse genetic approach to open the way for thermostable FMD vaccine. The crucial amino acid residues those are located at, or very close to, the inter-subunit interfaces of the FMD viral capsid were changed by site-directed mutagenesis. Thermostable mutant of serotype O FMD virus IND R2/1975 was produced and characterised at laboratory level at ICAR-DFMD, Mukteswar and satisfied all the parameters. However, the vaccine worth attributes and animal (cattle) efficacy study was carried out in collaboration with IVRI regional station Bengaluru.

With regard to evaluating thermostable



**Fig. 6.1:** Detection of recombinant 2A-HA epitope-tagged chimeric FMDV by indirect immunofluorescence assay (IFA). BHK-21 cells were infected either with HA-tagged recombinant or non-tagged parental virus @ m.o.i. 0.5 for 5 h. Detection of IFA was performed using rabbit anti-HA antibodies as primary and goat anti-rabbit IgG, Alexa Fluor® 488 (Invitrogen, USA) secondary antibody (green colour). The cellular nuclei were visualized with 4',6'-diamidino-2-phenylindole (DAPI, blue colour).



**Fig. 6.2.1:** Cartoon representation of atomic structure of FMDV O IND R2/1975 capsid with two pentameric subunits delineated to show the inter-pentameric interface. The crucial amino acid residues responsible for enhanced thermostability have been depicted in blue (VP2-93) and yellow color (VP2-98)

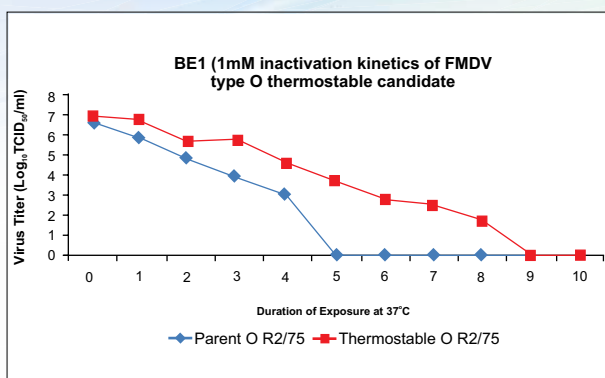
FMDV type O candidate as vaccine, attributes such as genetic stability, antigenic stability, thermal inactivation kinetics, BEI inactivation kinetics and capsid stability on inactivation were studied. It was observed that thermostable mutant FMD virus remained genetically and antigenically stable as demonstrated by nucleic acid sequencing (upto 10 serial passages) and cross neutralization assay. **Thermal inactivation kinetics** at 45°C, 37°C and 26°C revealed comparatively better thermostability of thermostable FMDV type O candidate than its parent virus (Table 6.1). It is to mention that highly thermostable virus loses infectivity, so cannot be used as vaccine candidate. **Virus inactivation kinetics** was studied with 3mM and 1mM concentration of BEI. While 3mM BEI inactivated both thermostable candidate and parent virus in 4 hours, it took about 9 hours to inactivate thermostable candidate and 5 hours for parent virus when 1mM BEI was used (Fig. 6.2.2 and Fig. 6.2.3). Though thermostable virus exhibited superior thermal inactivation kinetics with respect to virus titres on exposure to different temperatures, 146S content, as estimated by CsCl density gradient method, did not show apparent superiority over parent virus when antigen mass of virus exposed to 37°C with and without BEI were compared (Table 6.2).

To assess the efficacy of the thermostable vaccine, a short term immunity study was conducted in cattle aged 1-2 years. Antibody titre in serum samples was estimated at 28 days post vaccination and the titres were comparable in both

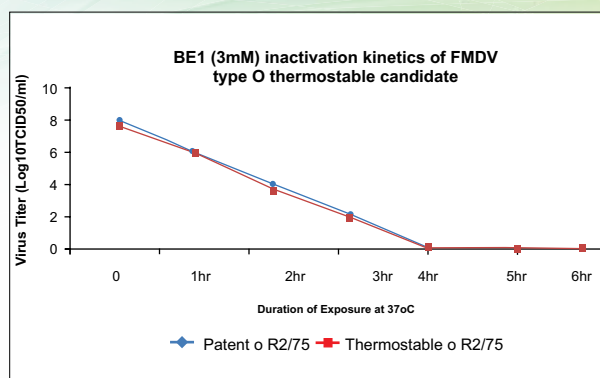
thermostable and parent type O vaccinated animals. Upon challenge with parent O virus, 5/6 animals were protected in thermostable vaccine group as against 6/6 in parent O vaccine group.

**Table 6.1** Comparison of thermal inactivation kinetics of Thermostable type O virus with its parent virus at different temperature

Temp	Time (hrs)	Virus titer ( $\text{Log}_{10} \text{TCID}_{50}$ )	
		Parent type O	Thermostable type O
45°C	0	6.8	7.05
	0.5	6.3	7.05
	1	5.55	6.8
	1.5	5.05	6.3
	2	4.55	5.8
	2.5	4.05	5.3
	3	3.8	5.05
	3.5	3.3	4.3
	4	3.05	4.3
	<b>Log reduction</b>	<b>3.75</b>	<b>2.75</b>
37°C	0	7.8	7.3
	2	7.63	6.97
	4	6.97	6.8
	6	6.8	6.8
	8	6.8	6.63
	10	6.53	6.3
	12	6.3	6.3
	15	5.97	5.97
	24	5.8	5.8
	<b>Log reduction</b>	<b>2</b>	<b>1.5</b>
26°C	0	7.8	7.3
	12	7.53	7.3
	24	6.97	6.63
	36	6.8	6.63
	48	6.97	6.53
	60	6.3	6.3
	72	5.97	6.3
	<b>Log reduction</b>	<b>1.83</b>	<b>1</b>



**Fig. 6.2.2:** Virus inactivation kinetics, BEI (1mM) inactivation kinetics of FMDV type O thermostable candidate. TCID<sub>50</sub>: Tissue Culture Infective Dose 50; BEI: Binary Ethyleneimine.



**Fig. 6.2.3:** Virus inactivation kinetics, BEI (3mM) inactivation kinetics of FMDV type O thermostable candidate. TCID<sub>50</sub>: Tissue Culture Infective Dose 50; BEI: Binary Ethyleneimine.

## 6.2.2 Development of FMDV serotype Asia1 Marker virus candidate and companion diagnostic

Inactivated purified whole virus vaccines are used for control of FMD. ELISAs detecting antibodies to the nonstructural proteins (NSP), a marker of infection, are primarily used to differentiate FMD virus (FMDV) infected from vaccinated animals (DIVA). However, such DIVA assays have a limitation to their specificity since residual NSPs present in the relatively impure vaccines are suspected to induce an NSP-antibody response in the repeatedly vaccinated animals. Epitope-deleted negative marker vaccine strategy seems to have an advantage over the conventional vaccines in identifying the infected animals with accuracy. NSP 3AB contains an abundance of immunodominant B-cell epitopes of diagnostic importance. This study addresses the feasibility of producing 3AB-truncated FMDV mutant as a potential negative marker vaccine candidate. An infectious cDNA clone of FMDV serotype Asia 1 strain was used to engineer an array of deletion mutations in the established antigenic domain of 3AB. The maximum length of deletion tolerated by the virus was found to be restricted to amino acid residues 87-144 in the C-terminal half of 3A protein along with deletion of the first two copies of 3B peptide. The 3AB-truncated marker virus (Asia 1 IND 491/1997Δ3A<sub>87-144</sub> 3B<sub>1,2</sub>+FLAG) demonstrated infectivity titres comparable to that of the parental virus in BHK-21 (log<sub>10</sub> 7.42 TCID<sub>50</sub>/ml) and LFBK-

α<sub>v</sub>β<sub>6</sub> (log<sub>10</sub> 8.30 TCID<sub>50</sub>/ml) cell monolayer culture. The protein fragment corresponding to the viable deletion in the 3AB region was expressed in a prokaryotic system to standardize a companion assay (3A<sub>87-153</sub> 3B<sub>1,2</sub> I-ELISA) for the negative marker virus which showed reasonably high diagnostic sensitivity (96.9%) and specificity (100% for naïve and 97.1% for uninfected vaccinated samples). The marker virus and its companion ELISA designed in this study provide a basis to devise a marker vaccine strategy for FMD control when the country reaches stage 4 of FMD PCP.

## 6.3 FMDV antigenic variation

### 3.3.1 Antigenic variability of FMDV during serial cytolitic passage

The emergence and disappearance of antigenic variants of FMDV during a field outbreak occurs periodically due to the volatile nature of its genome. In the present analysis, change in antigenic behaviour of serotype O FMDV field isolate (PD353/2011) during the serial cytolitic passage in the absence of immune pressure was observed. Initially, the isolate showed a poor antigenic match (relationship value <0.3) with the serotype O vaccine strain and upon serial passage increase in relationship value was observed. Comparison of capsid sequence revealed substitution at four positions (VP3:K<sub>58</sub> → E and P<sub>158</sub> → S, VP1:E<sub>83</sub> → K and R<sub>172</sub> → Q) acquired during the serial passage. Examination of passage level and amino acid substitution revealed the critical role of position VP3-58 that was identified

earlier as crucial for antigenic site IV, in the observed antigenic variability. The role of position VP3-58 was further confirmed using reverse genetics approach

## 6.4 FMDV Pathogenesis

### 6.4.1: Subclinical FMDV infection in young calves born from clinically recovered (convalescent) cow

It is known that an asymptomatic, persistent FMD virus (FMDV) infection may occur subsequent to acute or subclinical FMDV infection in adult ruminants. However, virus persistence in young calves has not been studied. In the current investigation, FMDV infection parameters were examined in calves born to FMD-clinically recovered cows (CRC), asymptomatic cows from infected herds (ASC) and cows from with no history of FMD (NHF). The study was conducted in natural condition after FMD outbreaks in two dairy herds. No calves described herein had any clinical signs of FMD. Six out of 12 calves born to CRC had detectable FMDV RNA in oesophageal-pharyngeal fluid consistent with asymptomatic FMDV infection. Three of the 12 calves of CRC group had seroreactivity against FMDV non-structural proteins. One calf had detectable FMDV RNA at two consecutive samplings at 2 months apart. However, infectious FMDV could not be isolated from any of the calves. None of the calves in the ASC or NHF groups had any evidence of FMDV infection.

### 6.4.2: FMD virus transmission dynamics and persistence in a herd of vaccinated dairy cattle in India

Although between herd transmission of the disease has been well studied, studies focusing on within herd transmission using farm level outbreak data are rare. The aim of this study was to estimate parameters associated with within herd transmission, host physiological factors and FMD virus (FMDV) persistence using data collected from an outbreak that occurred at a large, organized dairy farm. Of 1,836 regularly vaccinated, adult dairy cattle, 222 had clinical signs of FMD over a 39 days period. Assuming homogenous mixing, a frequency-dependent compartmental model of disease

transmission was built. The transmission coefficient and basic reproductive number were estimated to be between 16.2-18.4 and 67-88, respectively. Based on oropharyngeal fluid (probang) sampling and FMDV-specific RT-PCR, four of 36 longitudinally sampled animals (14%) were persistently infected carriers till 10.5 months post-outbreak. There was no statistical difference between subclinical and clinically infected animals in the duration of the carrier state. However, prevalence of NSP-ELISA antibodies differed significantly between subclinical and clinically infected animals 12 months after the outbreak with 83% seroprevalence amongst clinically infected cattle compared to 69% of subclinical animals.

## 6.5 FMDV surveillance

### 6.5.1: Phylogenetic characterization of FMDV recovered from mithuns and yaks

The yak and mithun husbandry in India is confronted with several challenges including the prevalence of FMD. The present study was initiated to investigate FMD outbreaks in semi-domesticated mithun and yak population in India. A total of 64 clinical samples (vesicle/tongue/foot epithelium/fluid) from mithun and 6 from yak were collected from suspected FMD outbreaks during 2008-2013. Supernatants of the homogenized clinical samples were tested in a serotype discriminating antigen detection ELISA and ELISA-negative samples were further subjected to multiplex reverse transcription-polymerase chain reaction (mRT-PCR). A total of 45 mithun samples and only 1 yak sample were found positive for serotype O in antigen detection ELISA. A total of 12 ELISA-negative samples from mithun and 4 from yak were later found positive for serotype O in mRT-PCR. The phylogenetic analysis based on VP1 genome indicated involvement of both O/ME-SA/PanAsia and O/ME-SA/Ind2001d sub-lineages of serotype O in those outbreaks. These viruses were genetically similar to those contemporary virus isolates responsible for FMD in domestic livestock indicating a situation of virus sharing among different species of domestic and semi-domestic animals. Mithun and yak may be included under FMDCP.



### 6.5.2: Molecular epidemiologic investigation of FMD in pig

FMD is a highly contagious and globally significant viral disease of livestock. The present study describes the results of molecular epidemiologic investigation of FMD in pigs across various states of India between 2008 and 2014. During this period, a total of 37 clinical epithelial samples (vesicle/foot/snout epithelium) of FMD-suspected pigs were tested in a serotype differentiating antigen detection ELISA and samples

found negative were further subjected to mRT-PCR. A total of 29 (78.37%) samples were found positive for serotype O in antigen detection ELISA and 8 ELISA negative samples were subsequently found positive for serotype O in mRT-PCR. The VP1 region based phylogenetic analysis demonstrated the involvement of O/ME-SA/Ind2001d sub-lineage in the outbreaks. The pig isolates clustered with the contemporary virus isolates collected from bovine indicating a close genetic relationship and therefore signifying inter-species transmission during the outbreaks.

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 121 serotype O virus isolates were added to the repository during the reported period (Table 7). At present the National FMD virus Repository holds a total of 2065 isolates (O-1482, A-325, C-15 and Asia 1-366).

**Table 7:** 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

# National FMD Sero-Surveillance

## 8.1 DIVA

During the year, a total of 42,010 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 ~21% samples/animals (Table 8.1.1). Till now, a total of 4,44,616 random serum samples from bovine have been analyzed by DIVA (Table 8.1.2).

**Table 8.1.1:** Summary of DIVA reactivity in bovine during 2017-18

Sl. No.	State	Total serum samples tested	Total positive	%3AB3 reactors
<b>Southern Region</b>				
1	Telangana	900	14	1.6
2	Tamil Nadu	6400	1622	25.3
<b>Central Region</b>				
3	Madhya Pradesh	10142	1822	18.0
<b>Western Region</b>				
4	Rajasthan	3510	1003	28.6
5	Maharashtra	2807	167	5.9
<b>Eastern Region</b>				
6	West Bengal	525	162	31.0
7	Jharkhand	555	312	56.2
8	Odisha	2700	1677	62.1
<b>Northern Region</b>				
9	Haryana	130	42	32.3
10	Uttarakhand	1078	75	7.0
11	Uttar Pradesh	2510	249	10.0
12	Himachal Pradesh	2210	589	26.7
13	Jammu and Kashmir	1710	315	18.4

Sl. No.	State	Total serum samples tested	Total positive	%3AB3 reactors
14	Punjab	2044	195	9.5
<b>North Eastern Region</b>				
15	Assam	1726	328	19.0
16	Manipur	1800	234	13.0
17	Mizoram	800	79	9.9
<b>Islands</b>				
18	Andaman and Nicobar	463	6	1.3
<b>Total</b>		<b>42010</b>	<b>8891</b>	<b>21.2</b>

**Table 8.1.2:** Year wise FMD outbreaks/incidences and percent DIVA positivity in India during last 15 years

Year	Number of outbreaks/incidences	% DIVA positivity
2002-03	2476	In 1995, 91% in cattle, 89% in sheep and 59% in goat. (FMDV 3D-VIA was used for DIVA)
2003-04*	1804	
2004-05	2894	
2005-06	1486	
2006-07	781	
2007-08	876	27.94
2008-09	245	
2009-10	599	
2010-11	176	
2011-12	347	
2012-13	331	
2013-14	472	
2014-15	76	
2015-16	252	
2016-17	150	
2017-18	169	21.2

\* Beginning of FMD control programme

There has been reduction in the number of outbreaks/incidences and severity of clinical

sickness after the implementation of FMDCP in the country. Built up of herd immunity in many areas under FMDCP has resulted in efficient virus clearance as evident from drop in DIVA reactivity over the period.

## 8.2 FMDV specific antibody level in random serum samples by SPC-ELISA

During the year under report, a total of 4446 random serum samples were subjected to Solid Phase Competitive ELISA (SPCE) for determination of antibody level against structural protein (SPs) of serotypes O, A and Asia1. Besides, 3182 serum samples received from various breeding bull station and random samples were tested (Table 8.2).

The data reveals very good FMD virus specific antibody level in the Maharashtra state (MS) followed by Mizoram. The serum samples collected in Assam, Uttarakhand and Tripura revealed very low level of FMDV specific

antibodies, and it indicates poor vaccination coverage.

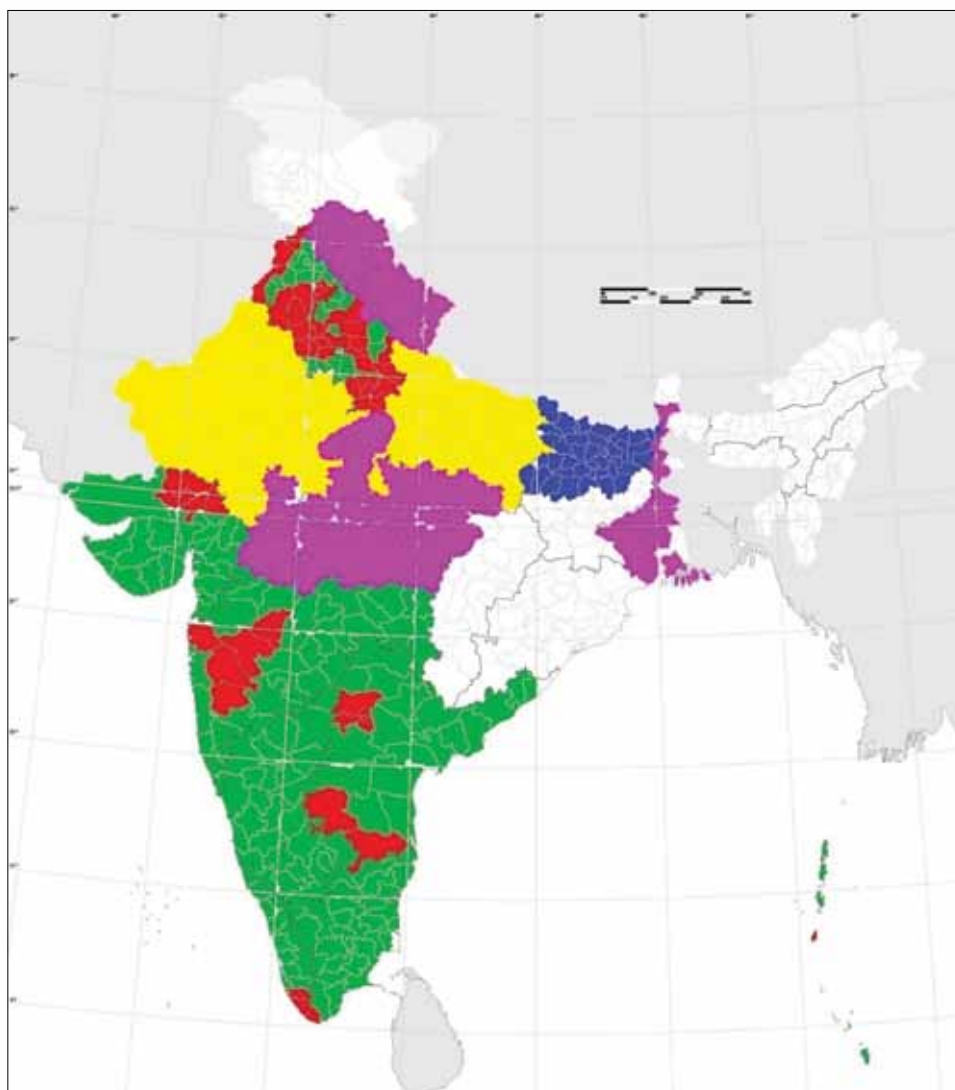
**Table 8.2: Summary of SPCE result obtained on Random serum samples.**

State	Species	No. of samples	Number & % animals (in bracket) showing titres $\geq 1.8 \log_{10}$ against FMDV		
			O	A	Asia1
Assam	Bovine	1017	204 (20.0)	102 (10.0)	141 (13.9)
Mizoram	Bovine	663	479 (72.2)	494 (74.5)	563 (84.9)
Maharashtra	Bovine	985	901 (91.5)	890 (90.4)	910 (92.4)
Uttarakhand	Bovine	1461	536 (36.7)	355 (24.3)	357 (24.4)
Tripura	Bovine	320	34 (10.6)	8 (2.5)	12 (3.8)

# 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



**Fig. 9.1:** Phases of FMD Control Program. **Phase I:** 54 districts were covered since the year 2004 (filled Red). **Phase II:** 167 districts were covered since the year 2011 (filled Green). **Phase III:** 110 districts were covered since the year 2014 (filled Yellow). **Phase IV:** 38 districts were covered since the year 2016 (filled Blue). **Phase V:** 91 districts were covered since the year 2016 (filled Pink). **Phase VI:** 308 districts were covered since the year 2017 (filled white).

of occurrence of FMD and DIVA status. Due to initial success 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 (LPBE) 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 seromonitoring 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.

**Table 9.1:** Number of serum samples tested to assess the levels of herd immunity and sero conversion. Till date 10, 02, 437 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 30, 07,311 tests were conducted.

Year	Number of serum samples tested	Number of test conducted
2005-11	1,28,127	3,84,381
2011-12	47,510	1,42,530
2012-13	1,55,611	4,66,833
2013-14	1,89,159	5,67,477
2014-15	1,91,402	5,74,206
2015-16	1,22,842	3,68,526
2016-17	7,996	23,988
2017-18	1,59,790	4,79,370

During 2017-18, using SPCE, a total of 1,59,790 serum samples (pre-vac: 80,268 and post-vac: 79,522) from the states of Punjab, Telangana, Andhra Pradesh, Maharashtra, Karnataka, Tamil Nadu, Kerala, Gujarat, Uttarakhand, Chhattisgarh, Rajasthan, Goa and Puducherry were tested under FMDCP seromonitoring.

## 9.2 Success indicator of FMDCP after 14 years in operation since 2003-04

- There were 1911 classical outbreaks of FMD when the FMDCP was initiated in the country in 2003-04. Now after 14 years, we have only about 150 incidences of FMD each in 2016-17 and 2017-18, indicating a 92% drop in the incidence/occurrence of the disease in the country. This is solely due to boost in herd immunity against the disease.
- Similarly, against a DIVA positivity of 91% in cattle, assessed during 1995, now the reactivity is reduced to 21.2% in 2017-18, indicating a reduction in DIVA reactors by about 77%. This data revealed progressive clearance of virus due to antibody pressure in vaccinated population/ areas.
- Against DIVA positivity of 89% in sheep and 59% in goat during 1995, now only ~18% of small ruminants are DIVA positive, indicating simultaneous clearance of virus from these animals.
- Both Delhi and Telengana state have DIVA positivity of <2%, followed by Maharashtra (<6%), Punjab (<10%), Kerala (17.5%), Uttar Pradesh (20%), Gujarat (21%), Andhra Pradesh (22.5%), Tamil Nadu (25%), Rajasthan (28%), Karnataka (30%) and Haryana (32%). This variation is due to primarily delay in vaccination aggravated by movement of bovines for trades.
- The performance of FMDCP is best in Delhi, followed by Telengana state, Punjab, Andhra Pradesh, Gujarat and Maharashtra.

## 9.3 State wise details

### 1. Tamil Nadu:

The state of Tamil Nadu has 32 districts in which the district Kanyakumari alone was covered under FMDCP in Phase I and later rest of 31 districts were included in Phase II since 2011.

- A total of 66,236 pre-vac and 65,719 post-vac samples have been tested till now.
- However, the pre-vac antibody level (herd immunity) has dropped from >80% during 2014-15 to 53-70% during 2016-17. This is attributed to irregular vaccination and coverage. The overall DIVA reactivity has been >24% during 2014-18 that is indicative of stable virus circulation in the state. Such delay in virus clearance from a vaccinated area is again indicative of irregular vaccination and coverage.
- Decline in herd immunity after round 12 of vaccination.

**Table 9.3.1: Result of seroconversion in Tamil Nadu (Phase I)**

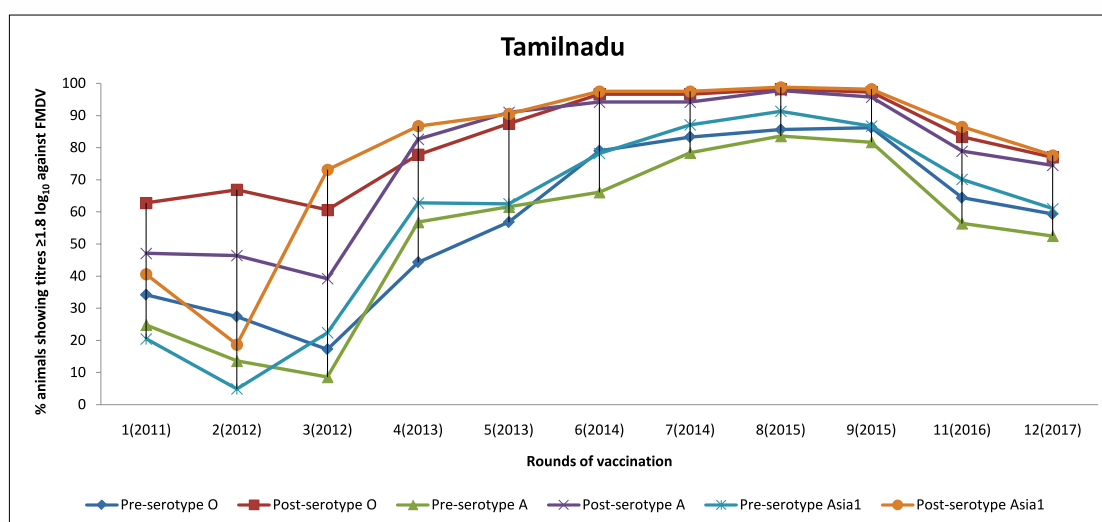
Tamil Nadu (Phase I)								
Vaccination Round	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2007)	100	100	28 (28)	51(51)	29 (29)	57 (57)	24 (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)

**Table 9.3.2: Result of seroconversion in Tamil Nadu (Phase II)**

Tamil Nadu (Phase II)								
Vaccination Round	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2011)	5440	5440	1860(34.2)	3417(62.8)	1351(24.8)	2561(47.1)	115(20.5)	2209(40.6)
2(2012)	5040	5240	1383(27.4)	3504(66.9)	684(13.6)	2433(46.4)	245(04.9)	979(18.7)
3(2012)	4600	4600	789(17.2)	2788(60.6)	396(08.6)	1801(39.2)	1030(22.4)	3361(73.1)
4(2013)	5801	5843	2570(44.3)	4547(77.8)	3296(56.8)	4826(82.6)	3643(62.8)	5066(86.7)
5(2013)	7199	6397	4089 (56.8)	5598(87.5)	4434(61.6)	5816(91)	4501(62.5)	5788(90.5)
6(2014)	6400	6400	5041 (79.0)	6180(96.6)	4230(66.1)	6028(94.2)	5002(78.2)	6240(97.5)
7(2014)	6400	6400	5332 (83.3)	6180 (96.6)	5016 (78.4)	6028 (94.2)	5572 (87.1)	6240 (97.5)
8(2015)	6400	6400	5480 (85.6)	6287 (98.2)	5348 (83.6)	6259 (97.8)	5845 (91.3)	6322 (98.8)
9(2015)	6400	6400	5517 (86.2)	6224 (97.3)	5230 (81.7)	6126 (95.7)	5547 (86.7)	6282 (98.2)
11(2016)	6156	6199	3967(64.4)	5172(83.4)	3472(56.4)	4891(78.9)	4318(70.1)	5364(86.5)
12(2017)	6400	6400	3798(59.3)	4930(77.0)	3366(52.5)	4770(74.5)	3907(61.0)	4964(77.6)

**Table 9.3.3: FMD incidences and DIVA reactors in Tamil Nadu**

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	16	16	-	-	NA
2007-08	201	199	1	1	NA
2008-09	Nil	-	-	-	24.4
2009-10	Nil	-	-	-	NA
2010-11	13	13	-	-	19.7
2011-12	7	7	-	-	29.0
2012-13	10	4	-	6	46.0
2013-14	48	48	-	-	20.0
2014-15	Nil	-	-	-	24.3
2015-16	1	1	-	-	27.2
2016-17	Nil	-	-	-	27.7
2017-18	1	1	-	-	25.3


**Fig. 9.3.1: Result of seroconversion in Tamil Nadu (Phase II)**

## 2. Karnataka:

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

- A total of 64,304 pre-vac and 64,427 post-vac samples have been tested till now.
- Overall, the herd immunity and seroconversion is not satisfactory at the end of 13<sup>th</sup> round (2017) of vaccination.
- The pre-vac antibody titre has dropped to 45-53% before 13<sup>th</sup> round of vaccination and post-vac antibody titre after 13<sup>th</sup> round of vaccination

has also dropped to <70%. This is a serious issue as during 12<sup>th</sup> round of vaccination both pre-vac and post-vac antibody titre were good, that is 74-88% in pre-vac serum samples and 84-90% in post-vac serum samples.

- This is indicative of poor vaccination coverage during 13<sup>th</sup> round of vaccination.
- Further DIVA reactivity is maintained at >30% during last three years (2014-17) that indicates stable virus circulation in the state of Karnataka. This is the reason of frequent occurrence of FMD in the state. FMD vaccination has to be intensified.

- The number of incidences of FMD during 2017-18 has increased to 93 from 42 in 2016-17 that also indicates active virus circulation in the state.
- DIVA reactivity of >30% is a serious matter and this value has to drop to <5% at the earliest.

**Table 9.3.4:** Result of seroconversion in Karnataka

Round of vaccination	Number of serum samples		Number and % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ 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)	-	1996	-	1936(97.0)	-	1895(94.9)	-	1958(98.1)
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)

**Table 9.3.5:** FMD incidences and DIVA reactors in Karnataka

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	33	24	9	-	NA
2007-08	91	70	21	-	58.2
2008-09	24	23	1	-	45.8
2009-10	22	22	-	-	48.4
2010-11	27	27	-	-	46.0
2011-12	52	43	1	8	58.0
2012-13	42	28	5	9	17.6
2013-14	116	116	-	-	21.1
2014-15	10	10	-	-	33.2
2015-16	50	47	3	-	34.2
2016-17	42	42	-	-	30.8
2017-18	93	93	-	-	Not tested

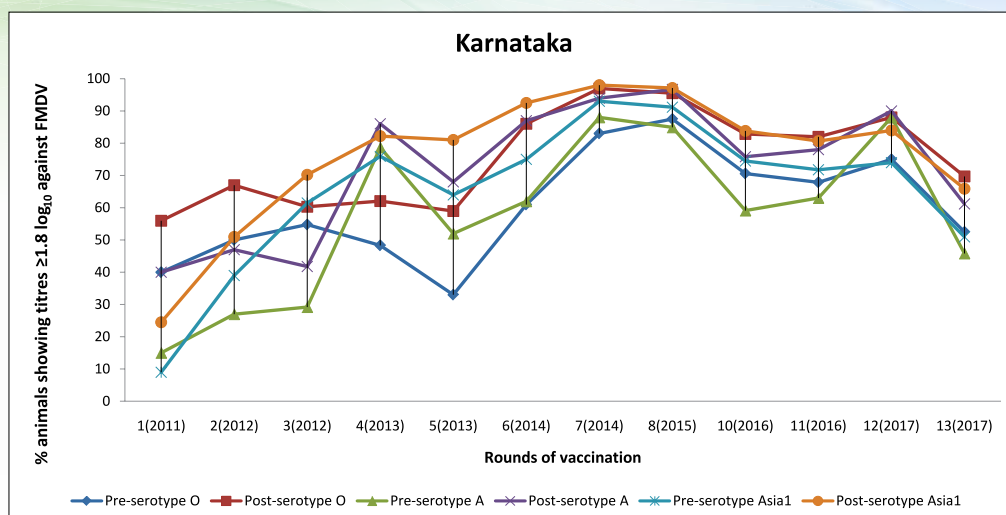


Fig. 9.3.2: Result of seroconversion in Karnataka.

### 3. 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 19,669 pre-vac and 18,439 post-vac samples have been tested till now.
- Overall, the herd immunity is found to be satisfactory at the end of 12<sup>th</sup> round.
- The pre-vac antibody titre (herd immunity)

has dropped to 52-62% before 12<sup>th</sup> round of vaccination from >75% earlier.

- This drop in pre-vac antibody titre is attributed to delay in vaccination/improper vaccination coverage.
- The post-vac antibody titre after 12<sup>th</sup> round is good at >83%, indicating good seroconversion and proper vaccination.
- DIVA reactivity at less than the national average of 21.2% (17.5%) during 2016-17 is a good sign and this has to drop to >5% at the earliest.

Table 9.3.6: Result of seroconversion in Kerala (Phase I)

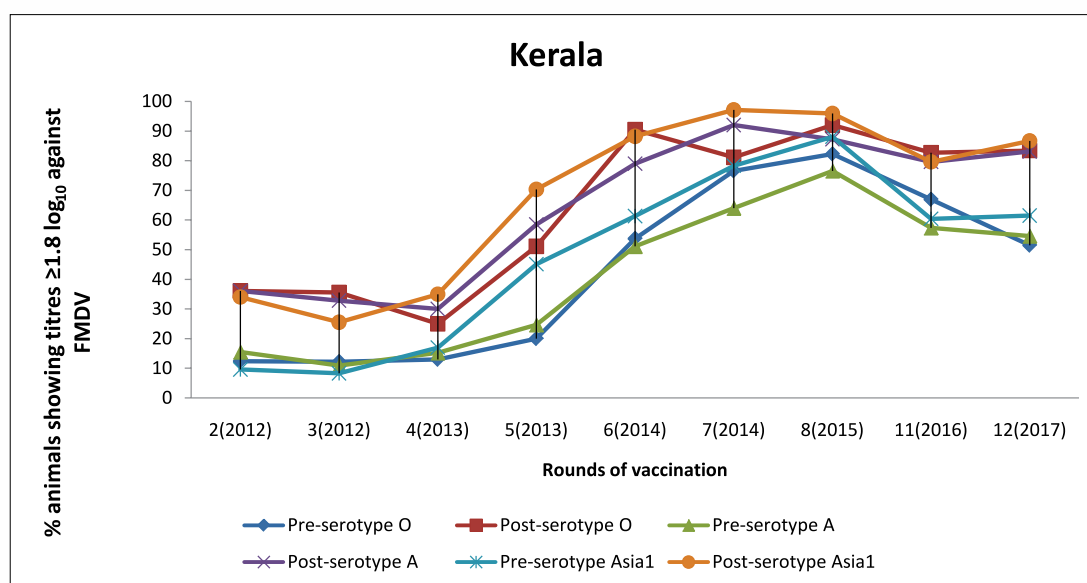
Kerala (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2006) & 2(2007) & 4(2008)	483	496	158(32.7)	255(51.4)	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)

**Table 9.3.7: Result of seroconversion in Kerala (Phase II)**

Kerala (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2(2012)	676	180	84(12.4)	65(36.1)	105(15.5)	65(36.1)	65(9.6)	61(34.0)
3(2012)	1631	1474	199(12.2)	525(35.6)	178(10.9)	484(32.8)	135(8.3)	376(25.5)
4(2013)	2378	2109	308(13.0)	526(25.0)	362(15.2)	633(30.0)	404(17.0)	735(35.0)
5(2013)	2043	1941	400(20.0)	991(51.1)	505(24.7)	1135(58.5)	922(45.1)	1364(70.3)
6(2014)	2789	2738	1498(53.7)	2479(90.5)	1425(51.1)	2164(79.0)	1709(61.3)	2415(88.2)
7(2014)	2791	2678	2137(76.6)	2173(81.1)	1786(64.0)	2462(92.0)	2184(78.3)	2600(97.1)
8(2015)	2800	2800	2303 (82.3)	2575 (92.0)	2145 (76.6)	2441(87.2)	2467 (88.1)	2686(95.9)
11(2016)	2361	2321	1581(67.0)	1920(82.7)	1355(57.4)	1847(79.6)	1427(60.4)	1847(79.6)
12 (2017)	2200	2198	1134(51.5)	1834(83.4)	1201(54.6)	1827(83.1)	1353(61.5)	1905(86.7)

**Table 9.3.8: FMD incidences and DIVA reactors in Kerala**

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	86	70	10	6	NA
2007-08	102	94	7	1	NA
2008-09	27	15	12	-	9.2
2009-10	25	19	6	-	15.1
2010-11	8	8	-	-	47.8
2011-12	35	34	-	1	22.9
2012-13	15	7	-	8	29.9
2013-14	50	50	-	-	44.4
2014-15	Nil	-	-	-	6.9
2015-16	38	38	-	-	NA
2016-17	7	7	-	-	17.5
2017-18	7	6	-	1	NA

**Fig. 9.3.3: Result of seroconversion in Kerala (Phase I)**

## 4. Andhra Pradesh:

Two districts of Andhra Pradesh (Ananthapur and Chittoor) 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 17,880 pre-vac and post-vac samples from united AP, 18,249 pre-vac and 18,250 post-vac samples from new AP have been tested till now.
- The herd immunity after 13<sup>th</sup> round of vaccination is very low at 31-40%. Such low level of herd immunity is dangerous as there is increased risk of virus incursion into the state and cause outbreaks.
- The vaccination intensity (Time and Density) has to be enhanced to build up protective herd immunity
- DIVA reactivity in the new AP state is 22.5% that is more than the national average of 21.2%. It has to drop to >5% at the earliest.
- 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 9.3.9: Result of seroconversion in Combined Andhra Pradesh (Phase I)**

Combined Andhra Pradesh (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ 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)

**Table 9.3.10: Result of seroconversion in Combined and new Andhra Pradesh (Phase II)**

Combined Andhra Pradesh (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ 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)	3600	3600	1043 (29.0)	2396 (66.5)	648 (18.0)	2030 (56.4)	419 (13.1)	1709 (47.5)
2(2012)	3480	3480	1435 (41.2)	2381 (68.4)	1026 (29.5)	2054 (59.0)	595 (17.1)	1499 (43.1)
3(2012)	3600	3600	1392 (38.6)	2498 (69.3)	750 (20.8)	1661 (46.1)	393 (10.9)	1162 (32.2)
4(2013)	3600	3600	1364 (38.0)	2354 (65.4)	1356 (37.7)	2821 (78.4)	1663 (46.2)	2788 (77.4)
5(2013)	3600	3600	1546 (42.9)	2478 (68.6)	2292 (63.6)	3153 (87.5)	2574 (71.5)	3239 (89.9)

Combined Andhra Pradesh (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
New Andhra Pradesh (Phase II)								
6(2014)	1800	1800	1053(58.5)	1359(75.5)	850(47.2)	1211(67.2)	1023(56.8)	1269(70.5)
7(2014)	1800	1800	1224(68.0)	1453(80.7)	825(45.8)	1302(72.3)	1189(66.0)	1492(82.8)
8(2015)	1800	1800	1303(72.3)	1563(86.8)	997(55.3)	1481(82.2)	1242(69.0)	1567(87.1)
9(2015)	2595	2598	1372(52.9)	1869(71.9)	961(37.0)	1528(58.8)	1243(47.9)	1861(71.8)
10(2016)	2598	2596	1609(61.9)	1965(75.7)	1303(50.2)	1735(66.8)	1427(54.9)	1793(69.1)
11(2016)	2480	2480	1274(51.4)	1581(63.8)	887(35.8)	1339(54.0)	1096(44.2)	1561(63.0)
12(2017)	2576	2576	1260(48.9)	1553(60.3)	780(30.3)	1158(45.0)	1182(45.9)	1567(60.8)
13(2017)	2600	2600	925(35.6)	1452(55.8)	799(30.7)	1341(51.6)	1040(40.0)	1560(60.0)

Table 9.3.11: FMD incidences and DIVA reactors in combined AP

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	89	76	3	10	NA
2007-08	51	47	-	4	10.0 (combined AP)
2008-09	13	13	-	-	21.4 (combined AP)
2009-10	12	10	2	-	21.3 (combined AP)
2010-11	3	2	1	-	19.4 (combined AP)
2011-12	3	3	-	-	24.3 (combined AP)
2012-13	1	1	-	-	23.2 (combined AP)
2013-14	13	13	-	-	42.8 (combined AP)
2014-15	Nil	-	-	-	30.5 (combined AP)
2015-16	Nil	-	-	-	Not tested
2016-17	Nil	-	-	-	22.5 (new AP)
2017-18	Nil	-	-	-	Not tested

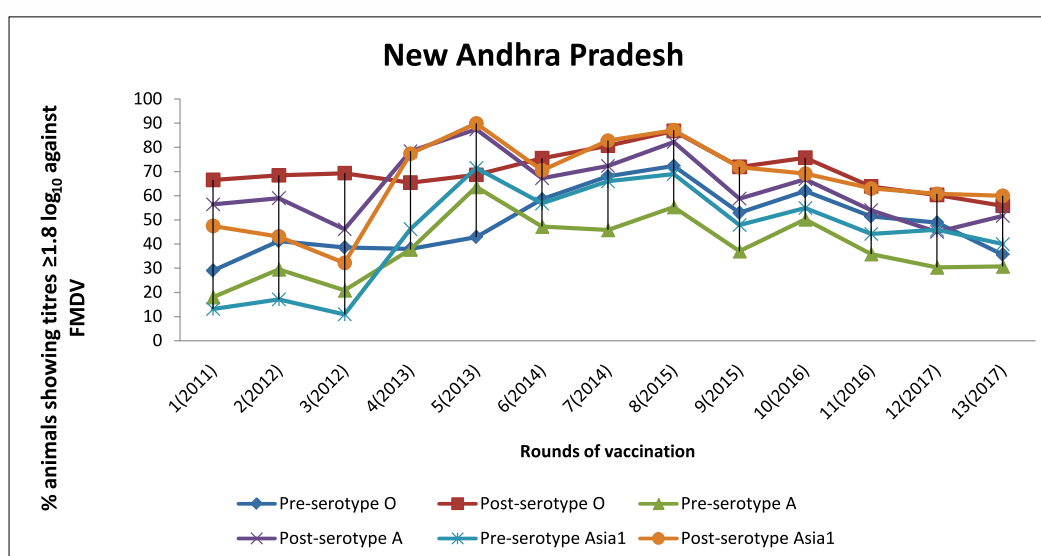


Fig. 9.3.4: Result of seroconversion in Combined and new Andhra Pradesh (Phase II)

## 5. Telangana state (TS):

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 17,880 pre-vac and post-vac samples from united AP, 10,775 pre-vac and 10,648 post-vac samples from Telangana state have been tested till now.
- The herd immunity is good at 60-73% before 12<sup>th</sup>

round of vaccination (2017). seroconversion after 12<sup>th</sup> round also good at 72-87%.

- This has resulted in efficient virus clearance as evident from drop in DIVA reactivity from 9% during 2016-17 to <2% during 2017-18.
- This level needs to be maintained for final clearance of virus from the TS.
- Increase in herd immunity compared to the previous round is encouraging.

**Table 9.3.11: Result of seroconversion in Combined Andhra Pradesh (Phase I)**

Combined Andhra Pradesh (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ 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)

**Table 9.3.12: Result of seroconversion in Combined Andhra Pradesh and Telangana state (Phase II)**

Combined Andhra Pradesh (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ 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)	3600	3600	1043 (29.0)	2396 (66.5)	648 (18.0)	2030 (56.4)	419 (13.1)	1709 (47.5)
2(2012)	3480	3480	1435 (41.2)	2381 (68.4)	1026 (29.5)	2054 (59.0)	595 (17.1)	1499 (43.1)
3(2012)	3600	3600	1392 (38.6)	2498 (69.3)	750 (20.8)	1661 (46.1)	393 (10.9)	1162 (32.2)
4(2013)	3600	3600	1364 (38.0)	2354 (65.4)	1356 (37.7)	2821 (78.4)	1663 (46.2)	2788 (77.4)
5(2013)	3600	3600	1546 (42.9)	2478 (68.6)	2292 (63.6)	3153 (87.5)	2574 (71.5)	3239 (89.9)
Telangana state (Phase II)								
6(2014)	1400	1400	902 (64.4)	1194 (85.2)	813 (58.0)	1095 (78.2)	873 (62.3)	1118 (79.8)

Combined Andhra Pradesh (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
7(2014)	1400	1400	1084(77.4)	1329(94.9)	1168(83.4)	1324(94.5)	1085(77.5)	1335(95.3)
8(2015)	1400	1400	1243(88.7)	1327(94.7)	1098(78.4)	1250(89.2)	1217(86.9)	1310(93.5)
9(2015)	1400	1400	1145(81.7)	1312(84.7)	1038(74.1)	1282(91.5)	1187(84.7)	1328(94.8)
10(2016)	1680	1636	1122(66.8)	1254(76.7)	965(57.4)	1168(71.4)	1100(65.5)	1215(74.3)
11(2017)	1680	1680	1041(61.9)	1307(77.8)	834(56.4)	1160(69.0)	972(57.9)	1332(79.3)
12(2017)	1795	1732	1311(73.0)	1505(86.9)	1059(60.0)	1252(72.3)	1168(65.1)	1412(81.5)

Table 9.3.13: FMD incidences and DIVA reactors in combined AP

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	89	76	3	10	NA
2007-08	51	47	-	4	10.0 (combined AP)
2008-09	13	13	-	-	21.4 (combined AP)
2009-10	12	10	2	-	21.3 (combined AP)
2010-11	3	2	1	-	19.4 (combined AP)
2011-12	3	3	-	-	24.3 (combined AP)
2012-13	1	1	-	-	23.2 (combined AP)
2013-14	13	13	-	-	42.8 (combined AP)
2014-15	Nil	-	-	-	30.5 (combined AP)
2015-16	Nil	-	-	-	33.9 (TS)
2016-17	Nil	-	-	-	9.0 (TS)
2017-18	Nil	-	-	-	1.6 (TS)

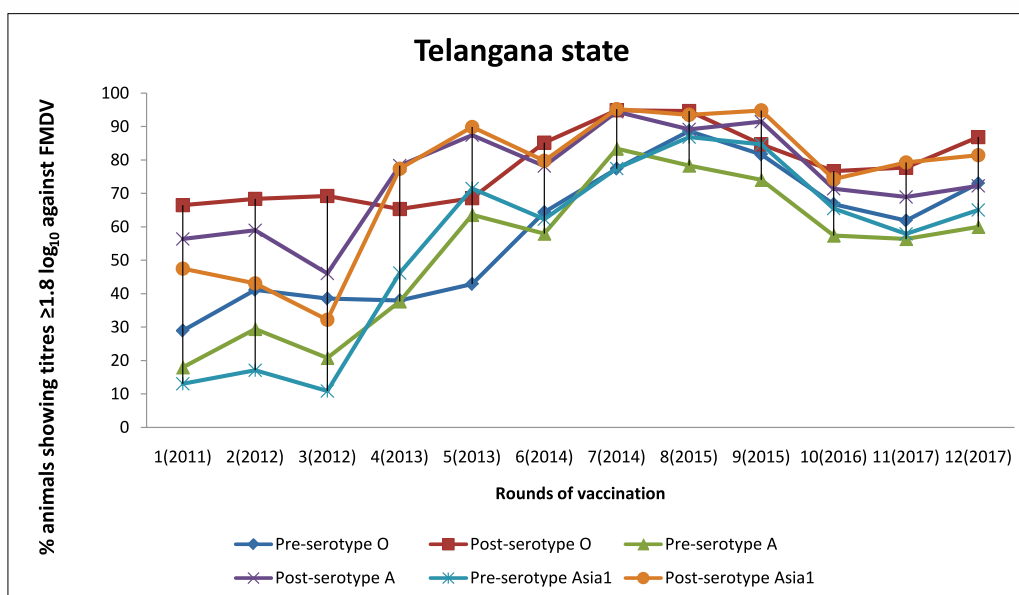


Fig. 9.3.5: Result of seroconversion in Combined Andhra Pradesh and Telangana state (Phase II)

## 6. 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 67,881 pre-vac and 68,092 post-vac samples have been tested till now.
- Overall, the herd immunity is low at 44-54% before the 11<sup>th</sup> round of vaccination.
- Decline in herd immunity compared to earlier

round (2016) is a concern and it is indicative of irregular vaccination and coverage.

- Post-vac seroconversion is good at 63-78%, almost similar to the previous year.
- 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.
- This story tells success of FMDCP in Maharashtra.

**Table 9.3.14: Result of seroconversion in Maharashtra (Phase I)**

Maharashtra (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ 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)

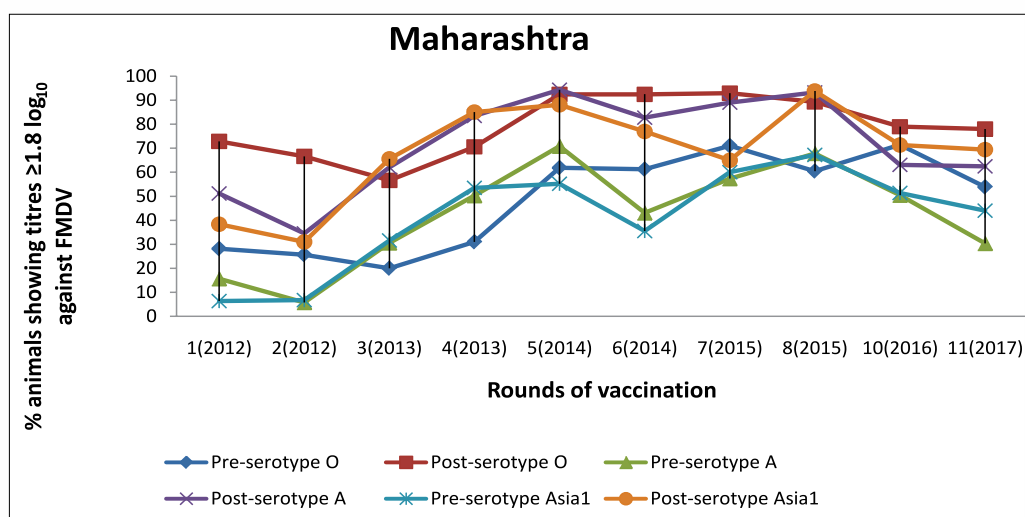
**Table 9.3.15: Result of seroconversion in Maharashtra (Phase II)**

Maharashtra (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2012)	5988	6018	1687(28.2)	4390(72.9)	941(15.7)	3080(51.2)	382(6.4)	2310(38.4)
2(2012)	7208	7341	1849(25.7)	4890(66.6)	481(05.8)	2530(34.5)	491(6.8)	2279(31)
3(2013)	4721	4723	938(20.0)	2674(56.6)	1444(30.6)	2933(62.1)	2674(31.6)	3096(65.6)
4(2013)	5250	5305	1673(31.0)	3746(70.6)	2641(50.3)	4429(83.5)	2809(53.5)	4513(85.1)

Maharashtra (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
5(2014)	4891	4891	3027(61.9)	4523(92.5)	3466(70.9)	4619(94.4)	2701(55.2)	4307(88.1)
6(2014)	5362	5362	3285(61.3)	4959(92.5)	2312(43.1)	4438(82.8)	1902(35.5)	4112(77.0)
7(2015)	4181	4181	2973(71.1)	3888(93.0)	2398(57.4)	3721(89.0)	2491(60.0)	2708(65.0)
8(2015)	5486	5486	3317(60.5)	4905(89.4)	3726(67.9)	5119(93.3)	3684(67.2)	5149(93.9)
10(2016)	4626	4590	3308(71.5)	3625(79.0)	2334(50.5)	2894(63.1)	2738(51.4)	3276(71.4)
11(2017)	1779	1759	959(53.9)	1372(78.0)	540(30.4)	1099(62.5)	782(44.0)	1222(69.5)

**Table 9.3.16:** FMD incidences and DIVA reactors in Maharashtra

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	13	6	1	6	NNAA
2007-08	17	11	1	5	
2008-09	10	4	1	5	37.2
2009-10	13	10	2	1	29.8
2010-11	8	6	-	2	50.3
2011-12	41	6	-	35	44.4
2012-13	5	-	-	5	21.8
2013-14	18	17	-	1	48.4
2014-15	Nil	-	-	-	28.3
2015-16	13	13	-	-	20.3
2016-17	Nil	-	-	-	25.9
2017-18	Nil	-	-	-	5.9


**Fig. 9.3.6:** Result of seroconversion in Maharashtra (Phase II)

## 7. 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 45,166 pre-vac and 44,314 post-vac samples have been tested till now.
- Overall, the herd immunity is low at ~42% before 11<sup>th</sup> round of vaccination (2017).
- Further, there is low seroconversion at 55-62%

after 11<sup>th</sup> round of vaccination that indicates poor vaccination and its coverage.

- There is decline in herd immunity (pre-vac titre) since the 10<sup>th</sup> round of vaccination (2016).
- There is no incidence of FMD in Punjab since 2011-12, and it commensurates with gradual decline in DIVA reactivity since 2012-13, and during 2017-18 it is much below (9.5%) the national average of 21.2%.
- This data generated shows the success of the control programme. However, the herd immunity has to reach >80%, by way of further intensive vaccination.

**Table 9.3.17: Result of seroconversion in Punjab (Phase I)**

Punjab (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(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)

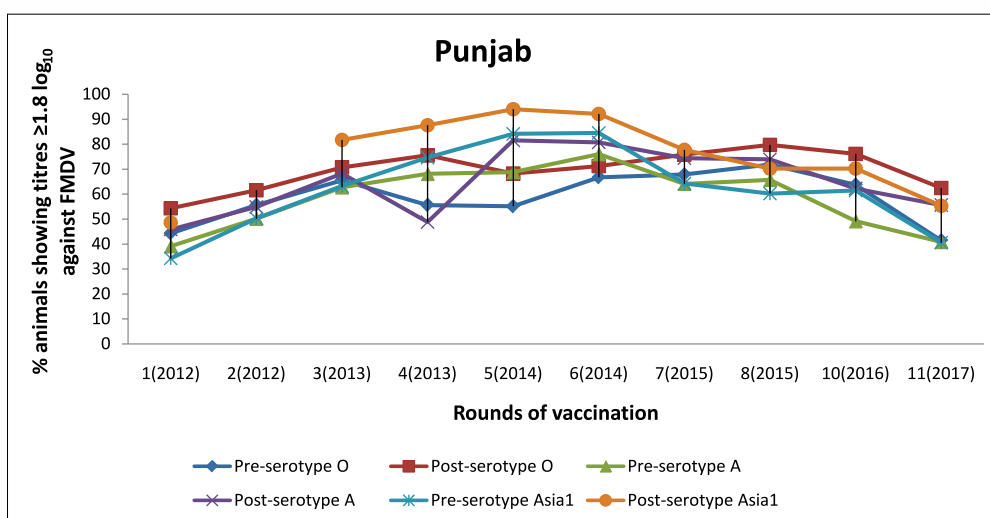
**Table 9.3.18: Result of seroconversion in Punjab (Phase II)**

Punjab (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2012)	1800	1800	797(44.3)	978(54.3)	704(39.1)	825(45.8)	615(34.2)	874(48.6)
2(2012)	1800	1782	1002(55.6)	1096(61.5)	902(50.1)	978(54.8)	904(50.2)	NT
3(2013)	1436	1195	940(65.5)	845(70.7)	900(62.7)	815(68.2)	908(63.2)	977(81.7)
4(2013)	2287	2110	1271(55.6)	1592(75.5)	1557(68.1)	1030(48.8)	1707(74.6)	1849(87.6)

Punjab (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
5(2014)	1975	1705	1088(55.1)	1162(68.2)	1359(68.8)	1389(81.5)	1660(84.1)	1602(94.0)
6(2014)	1872	1990	1248(66.7)	1416(71.2)	1423(76.0)	1606(80.7)	1582(84.5)	1832(92.1)
7(2015)	2126	2105	1442(67.8)	1595(75.8)	1363(64.1)	1567(74.4)	1365(64.2)	1626(77.7)
8(2015)	2400	2289	1724(71.8)	1824(79.7)	1577(65.7)	1692(73.9)	1444(60.2)	1608(70.2)
9(2016)	698	-	490 (70.8)	-	462 (66.2)	-	478 (68.5)	-
10(2016)	2352	2087	1498(63.7)	1588(76.1)	1155(49.1)	1298(62.2)	1445(61.4)	1466(70.2)
11(2017)	2654	3043	1100(41.4)	1898(62.4)	1083(40.8)	1693(55.6)	1078(40.5)	1684(55.3)

**Table 9.3.19:** FMD incidences and DIVA reactors in Punjab.

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	Nil	-	-	-	NA
2007-08	2	2	-	-	NA
2008-09	4	3	1	-	5.2
2009-10	1	-	1	-	12.4
2010-11	3	3	-	-	12.3
2011-12	Nil	-	-	-	Not tested
2012-13	Nil	-	-	-	11.4
2013-14	Nil	-	-	-	12.1
2014-15	Nil	-	-	-	9.7
2015-16	Nil	-	-	-	9.1
2016-17	Nil	-	-	-	9.9
2017-18	Nil	-	-	-	9.5



**Fig 9.3.7:** Result of seroconversion in Punjab (Phase II)

## 8. Rajasthan:

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

- A total of 9913 pre-vac and 9136 post-vac samples have been tested till now.
- The herd immunity and seroconversion was very good till the 3<sup>rd</sup> round of vaccination, and it has deteriorated in the subsequent year that indicates irregular vaccination and poor vaccine coverage.
- The herd immunity is very low at 23-31% before 5<sup>th</sup> round of vaccination (2017).
- The overall seroconversion after 5<sup>th</sup> round of vaccination is also low, and it indicates very poor vaccination.
- DIVA reactivity also high at 28% since 2007-08, that is more than the national average of 21.2%. This indicates stable virus circulation in the state, and this has to reduce to <5% at the earliest by the way of regular intensive vaccination.

**Table 9.3.20:** Result of seroconversion in Rajasthan

Rajasthan								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2(2016)	1996	2298	1069(53.6)	1915(83.3)	1199(60.1)	1634(71.1)	1276(63.9)	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)

**Table 9.3.21:** FMD incidences and DIVA reactors in Rajasthan

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	1	-	1	-	NA
2007-08	3	2	-	1	42.6
2008-09	Nil				36.8
2009-10	Nil				56.0
2010-11	4	3	-	1	53.0
2011-12	13	13	-	-	36.8
2012-13	7	5	-	2	40.0
2013-14	4	4	-	-	37.4
2014-15	2	2	-	-	26.6
2015-16	4	4	-	-	38.1
2016-17	1	1	-	-	35.7
2017-18	5	3	-	2	28.6

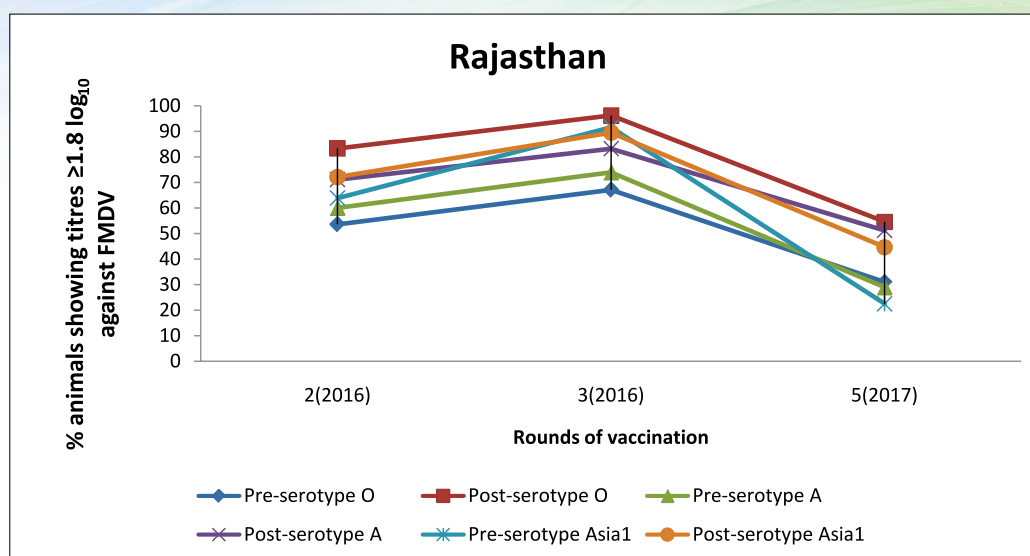


Fig. 9.8: Result of seroconversion in Rajasthan

## 9. Haryana:

Eight districts of Haryana namely, Bhiwani, Fatehabad, Hisar, Jhajjar, Jind, Rohtak, Sirsa and Sonapat 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 9.3.22: Result of seroconversion in Haryana (Phase I)

Haryana (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2(2005)	1558	1558	NA	1065(68.3)	NA	859 (55.1)	NA	831 (53.3)
3(2006)	1585	1585	NA	1146(72.3)	NA	1007(63.6)	NA	1005(63.4)
4(2006)	1589	1552	953 (60.1)	1222(78.7)	668 (42.1)	887 (57.1)	844(53.2)	1170(75.3)
5(2008)	1600	1599	955 (59.7)	1352(84.5)	813 (50.8)	1274(79.6)	941(58.8)	1353(84.5)
6(2008)	1496	1499	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)

Haryana (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
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	1439	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)	1360	1210	593(43.6)	975(80.6)	520(38.2)	989(81.7)	474(34.9)	896(74.1)
13(2012)	1590	1600	925(58.2)	654 (82.8)	218(27.6)	630(79.8)	185(23.4)	616(78.0)
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(63.8)	1020(69.1)	1476(96.7)	1106(92.3)	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)	1700	1100	1267 (74.5)	1055 (96.0)	1215 (71.5)	1005 (91.4)	1433 (84.3)	1079 (98.1)

**Table 9.3.23: Result of seroconversion in Haryana (Phase II)**

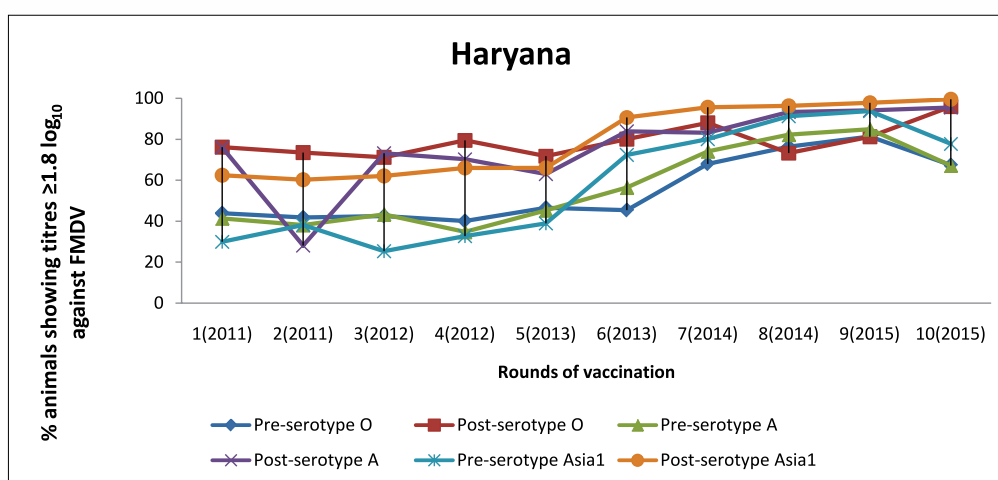
Haryana (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2011)	3086	2354	1049(43.9)	1790(76.1)	988(41.4)	1789(76.0)	715(30.0)	1469(62.4)
2(2011)	2586	2594	1081(41.8)	1876(73.5)	986(38.1)	727(28.1)	986(38.1)	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)	1907(73.3)	2138(82.2)	2427(93.3)	2371(91.2)	2506(96.3)
9(2015)	2600	2600	2113(81.3)	2112(81.2)	2208(84.9)	2447(94.1)	2439(93.8)	2542(97.8)

Haryana (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Serotype O		Serotype A		Serotype Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
10(2015)	2000	200	1347 (67.4)	192 (96.0)	1343 (67.2)	191 (95.5)	1555 (77.8)	199 (99.5)

Note: No serum sample received from Haryana after 2015

**Table 9.3.24: FMD incidences and DIVA reactors in Haryana**

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	1	1	-	-	NA
2007-08	2	-	2	-	18.4
2008-09	1	-	-	1	14.4
2009-10	2	1	1	-	26.4
2010-11	2	2	-	-	11.9
2011-12	4	4	-	-	8.3
2012-13	Nil	-	-	-	7.0
2013-14	2	2	-	-	2.1
2014-15	2	2	-	-	5.5
2015-16	1	1	-	-	9.0
2016-17	5	5	-	-	15.5
2017-18	5	5	-	-	32.3



**Fig. 9.3.9: Result of seroconversion in Haryana (Phase II)**

## 10. Uttar Pradesh (U.P.):

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 44,705 pre-vac and 32,855 post-vac samples have been tested till now.

- Herd immunity as well as seroconversion following vaccination is poor after 17<sup>th</sup> rounds of vaccination. Both values were <50%.
- In spite of very low herd immunity, 38-43%, the number of incidences as well as DIVA reactivity are low. This puts doubt on the nature of serum samples collected for DIVA, and improper disease surveillance in UP.
- This discrepancy needs to be examined by random re-sampling of serum.

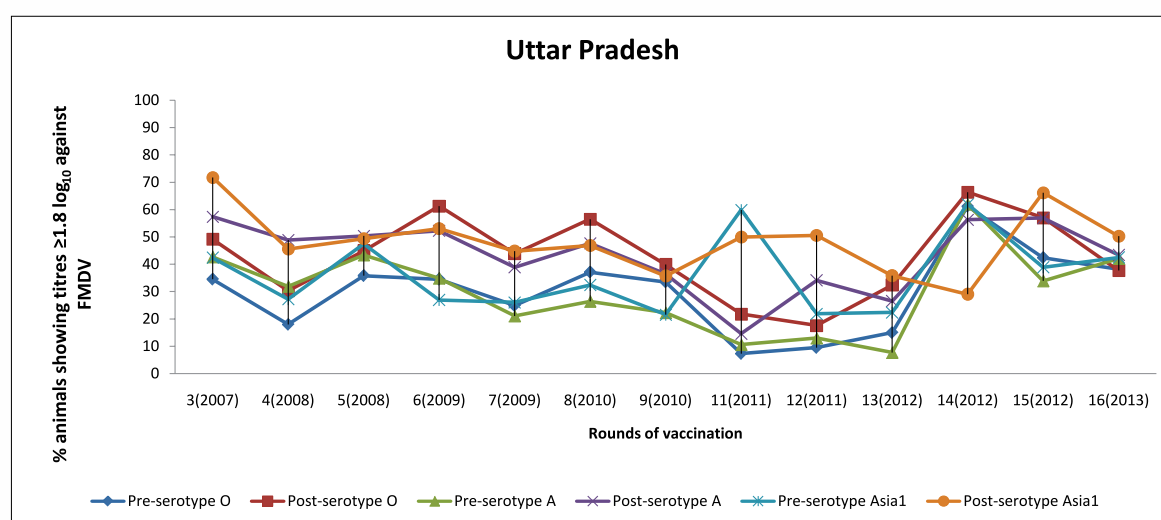
**Table 9.3.25: Result of seroconversion in Uttar Pradesh (Phase I)**

Uttar Pradesh								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ 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

Note: No serum sample received from UP after 2013

**Table 9.3.26:** FMD incidences and DIVA reactors in Uttar Pradesh

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	3	3	-	-	NA
2007-08	10	6	1	3	76.2
2008-09	3	2	1	-	NA
2009-10	48	36	7	5	NA
2010-11	2	2	-	-	28.0
2011-12	7	7	-	-	13.3
2012-13	4	3	1	-	19.6
2013-14	12	12	-	-	56.4
2014-15	1	1	-	-	45.9
2015-16	6	4	2	-	18.9
2016-17	1	1	-	-	15.8
2017-18	8	Not yet tested			10.0

**Fig. 9.3.10:** Result of seroconversion in Uttar Pradesh (Phase I)

## 11. Gujarat:

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

- A total of 35,792 pre-vac and 35,834 post-vac samples have been tested till now.
- Herd immunity is satisfactory (60-72%).
- There were a few incidences of FMD with a DIVA positivity of 21%.
- The state had <18% DIVA positivity with a single incidence of FMD in the year 2014-15. As the incidences increased to 06 during next year, DIVA positivity also increased to 40% indicating higher circulation of the virus in 2015-16.
- The data is a typical example of direct correlation between number of disease incidences and extent of DIVA reactivity/positivity.
- Gujarat is another example of success of FMDCP.

**Table 9.3.27: Result of seroconversion in Gujarat (Phase I)**

Gujarat (Phase I)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ 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(2007)	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(2008)	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(2009)	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(2010)	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(2011)	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)

**Table 9.3.28: Result of seroconversion in Gujarat (Phase II)**

Gujarat (Phase II)								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2012)	2007	2029	589(29.4)	1009(49.7)	407(20.3)	784(38.6)	670(33.4)	1011(49.8)
2(2012)	3974	4290	1748(44.0)	2545(59.3)	1354(34.1)	2224(51.8)	1393(35.1)	2095(48.8)
3(2013)	4700	4708	2652(56.4)	3164(67.2)	2237(47.6)	2946(62.6)	2245(47.8)	2754(58.5)
4(2013)	4600	4538	2506(54.5)	3444(75.9)	2874(62.5)	3491(76.9)	3183(69.2)	3688(81.3)
5(2014)	5200	5200	3093(59.5)	3869(74.4)	3260(62.7)	3971(76.4)	3376(74.9)	4160(80.0)
6(2014)	3600	3600	2695(74.9)	2937(81.6)	1786(49.6)	2369(65.8)	2722(65.6)	2861(79.5)
7(2015)	5000	5000	3000(60.0)	3556(73.1)	3081(61.6)	3728(74.6)	3620(72.4)	4031(80.6)

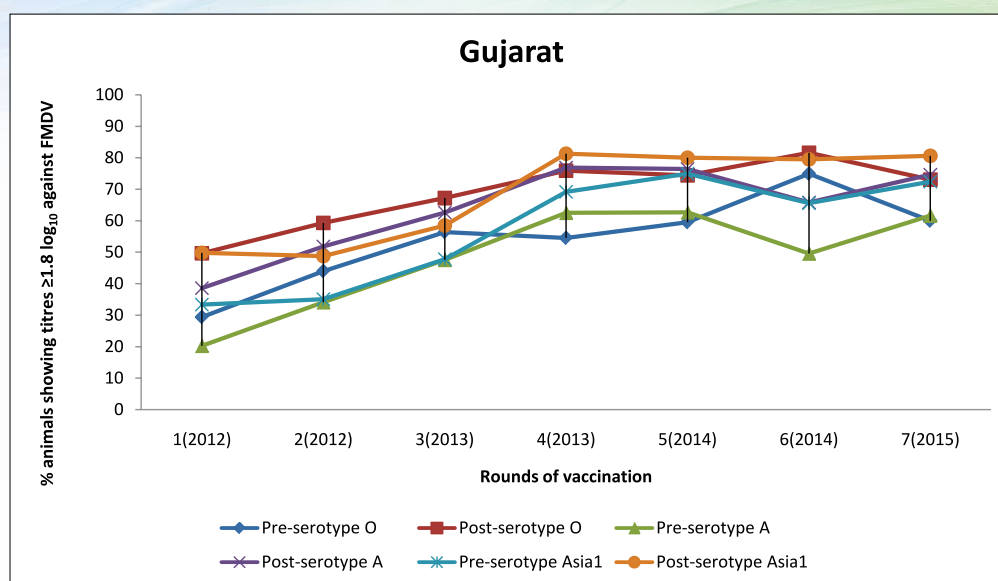


Fig. 9.3.11: Result of seroconversion in Gujarat (Phase II)

Table 9.3.29: FMD incidences and DIVA reactors in Gujarat

Year	Incidences	Serotypes			% DIVA reactor
		O	A	Asia1	
2006-07	15	13	1	1	NA
2007-08	11	9	-	2	NA
2008-09	6	6	-	-	33.0
2009-10	11	5	-	6	38.2
2010-11	6	5	-	1	19.3
2011-12	5	1	1	3	40.3
2012-13	2	2	-	-	41.0
2013-14	3	2	1	-	60.5
2014-15	1	1	-	-	17.6
2015-16	6	6	-	-	39.6
2016-17	5	5	-	-	20.9
2017-18	5	5	-	-	NA

## 12. Goa:

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

- The herd immunity is poor at 33-40% at 12<sup>th</sup> round, so also the seroconversion following vaccination is low (56-65%).

- The data revealed irregular vaccination and sub-optimal vaccination coverage.
- One incidence due to serotype Asia1 in 2011-12 and two incidences due to serotype A in 2013-14 was recorded.

Table 9.3.30: Result of seroconversion in Goa

Goa								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(2012)	391	381	47(12)	244(86.8)	8(2)	92(24.1)	11(2.8)	92(24.1)

Goa								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
2(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)
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)

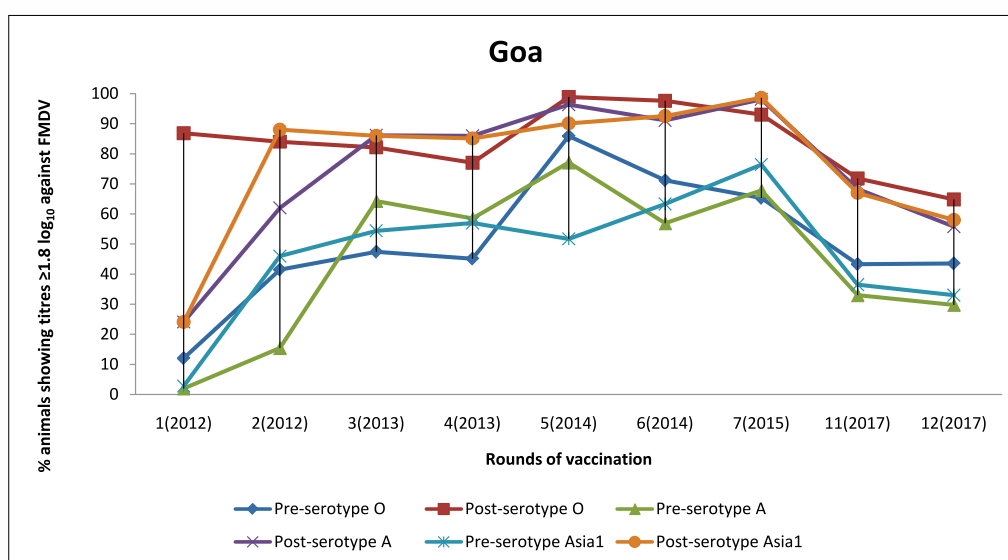


Fig. 9.3.12: Result of seroconversion in Goa

One incidence due to serotype Asia1 in 2011-12 and two incidences due to serotype A in 2013-14 was recorded.

### 13. Delhi:

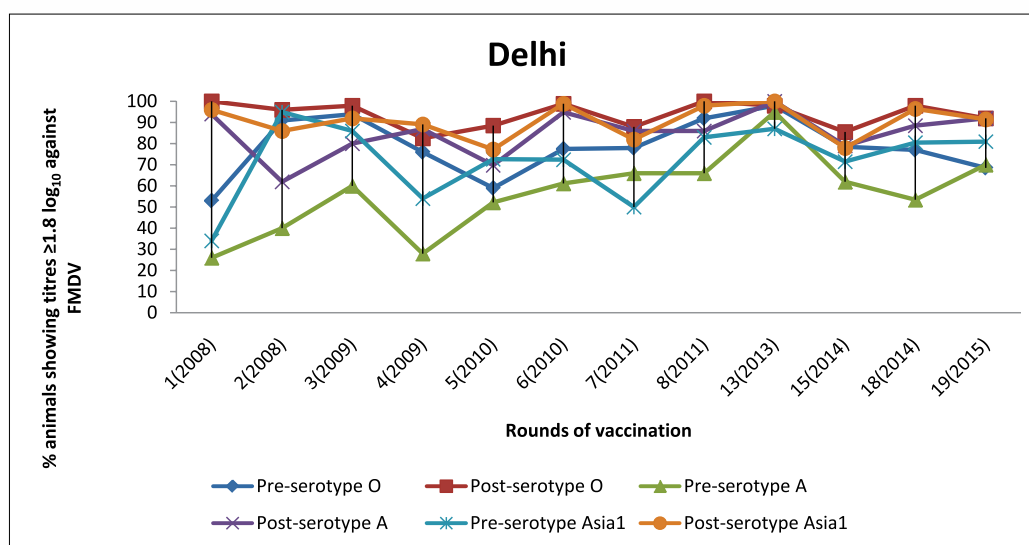
Delhi was included under FMDCP in Phase I since the year 2004.

- 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 19<sup>th</sup> 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 9.3.31: Result of seroconversion in Delhi**

Round of vaccination	Number of serum samples		Delhi					
			Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
	Pre	Post	Type O		Type A		Type Asia 1	
			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)

Note: No serum sample received from Delhi after 2015

**Fig. 9.3.13: Result of seroconversion in Delhi**

## 14. Lakshadweep:

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

**Table 9.3.32: Result of seroconversion in Lakshadweep**

Round of vaccination	Number of serum samples		Lakshadweep					
			Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
	Pre	Post	Type O		Type A		Type Asia 1	
			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

## 15. Puducherry:

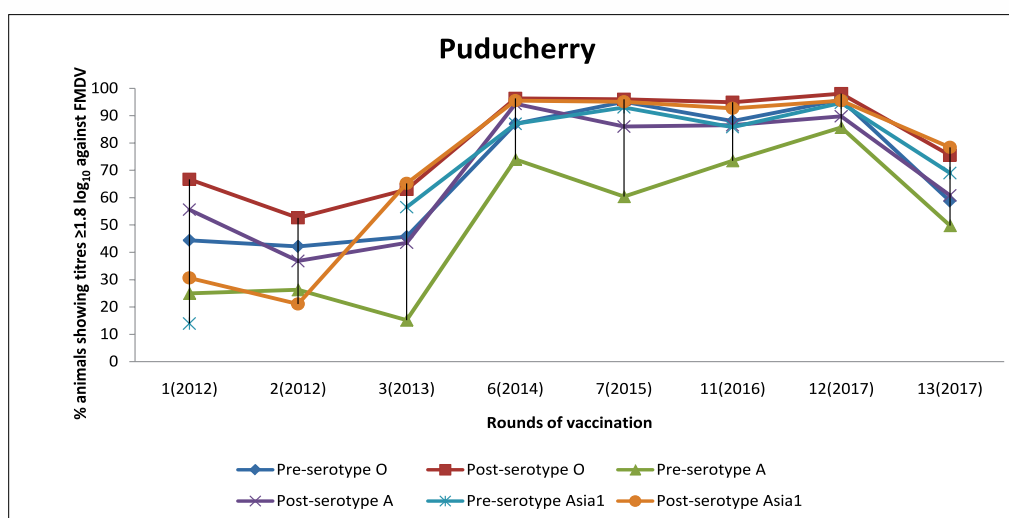
Puducherry was included under FMDCP in Phase II since 2011.

- A total of 1424 pre-vac and 1446 post-vac samples have been tested till now.

- Herd immunity was good between 2014-17, and it has dropped to <70% from >86% during 2017.
- Seroconversion has also dropped to 61-78% from >86%.
- Decline in herd immunity is a concern and vaccination has to be intensified.

**Table 9.3.33: Result of seroconversion in Puducherry**

Round of vaccination	Puducherry							
	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
			Type O		Type A		Type Asia 1	
	Pre	Post	Pre-vac	Post-vac	Pre-vac	Post-vac	Pre-vac	Post-vac
1(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)



**Fig. 9.3.14: Result of seroconversion in Puducherry**

## 16. 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.

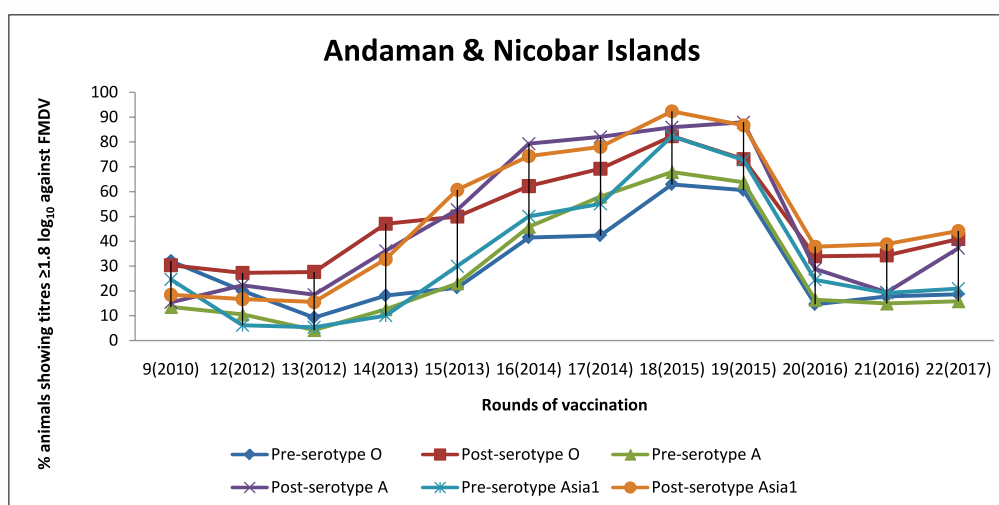
- A total of 7387 pre-vac and 6275 post-vac samples have been tested till now.
- The herd immunity has dropped during 2016 and 2017 and it is a matter of concern.
- It is also a matter of concern that the herd

immunity is very low at 16-21% during 2017, and it could lead to incidence of FMD in time to come.

- The last incidence of FMD in A&N was recorded in the year 2005.
- However due to very low herd immunity and very low seroconversion (37-44%), the island is under constant risk of re-currence of FMD.
- FMD virus can easily enter and establish again from West Bengal etc.

**Table 9.3.34:** Result of seroconversion in Andaman & Nicobar Islands

Andaman & Nicobar Islands								
Round of vaccination	Number of serum samples		Number & % animals (parenthesis) showing titres $\geq 1.8 \log_{10}$ against FMDV					
	Pre	Post	Type O		Type A		Type Asia 1	
			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(2016)	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)

**Fig. 9.3.15:** Result of seroconversion in Andaman & Nicobar Islands

## 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 (IND40/2000)} were bulk produced in roller culture vessels and purified by density gradient centrifugation. Antibodies against purified virus was raised and titrated against homologous as well as heterologous virus. Freeze dried and standardized serum antibodies (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 serosurveillance 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: Year wise supply of diagnostic kits**

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

# Research Projects

11

S. No.	Title	PI	Co-PI	Duration	Institute code
1.	Cataloguing and Maintenance of National Foot and Mouth Disease virus repository during 2018-19	B. Pattnaik	Shyam S Dahiya Saravanan S	2018-19	DFMD/1/2018
2.	Isolation and characterization of foot and mouth disease virus serotype O from India during 2018-19.	Shyam S Dahiya	Saravanan S. Sagar A. Khulape Aditya P. Sahoo	2018-19	DFMD/2/2018
3.	Genetic basis of the antigenic variation of genotype-18 (G-VII) of FMDV serotype A circulating in India	J. K. Biswal	Saravanan S	2018-19	DFMD/3/2018
4.	Genetic and antigenic analysis of Foot and Mouth Disease virus serotype Asia1 during 2018-19.	Sagar A. Khulape	Saravanan S R. Ranjan	2018-19	DFMD/4/2018
5.	Deep sequencing of FMD virus genome during 2018-19.	Sagar A. Khulape	Saravanan S. J.K. Biswal	2018-19	DFMD/5/2018
6.	Seromonitoring of pre and post vaccinal immunity against Foot and Mouth Disease virus during 2018-19.	J.K.Mohapatra	Saravanan S J. K. Biswal	2018-19	DFMD/6/2018
7.	Random serosurveillance of FMD in India during 2018-19.	Saravanan S	Aditya P. Sahoo J. K. Biswal M Rout	2018-19	DFMD/7/2018
8.	Epidemiology of Foot and Mouth Disease in small ruminants and pigs in India during 2018-19.	M. Rout	J.K.Mohapatra Saravanan S	2018-19	DFMD/8/2018
9.	Production, standardization and supply of diagnostic reagents for Foot and Mouth Disease virus diagnosis and surveillance during 2018-19.	Aditya P. Sahoo	Shyam S Dahiya J.K.Mohapatra R. Ranjan S. Mallick	2018-19	DFMD/9/2018
10.	Assessment of persistence of foot and mouth virus in animal through meta genomic approach	Aditya P. Sahoo	Sagar A. Khulape R. Ranjan	2018-19	DFMD/10/2018
11.	Identification of gene(s) and gene networks to unravel virus-host interactome associated with Foot and Mouth disease of cattle	Aditya P. Sahoo	Sagar A. Khulape Shyam S Dahiya J.K. Biswal S. Mallick	2018-19	DFMD/11/2018

S. No.	Title	PI	Co-PI	Duration	Institute code
12.	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
13.	Prokaryotic Expression of FMD virus like particles (VLP): A method for rapid and inexpensive production of FMD antigen in Bacteria	J. K. Biswal	R. Ranjan Aditya P Sahoo	2018-19	DFMD/13/2018
14.	Detection of subclinical infection of foot-and-mouth disease virus in goat under natural condition	R. Ranjan	J.K. Biswal	2017-19	DFMD/11/2017
15.	Understanding FMD viral ecology and landscape epidemiology towards control and eradication.	R. Ranjan	J.K. Biswal Saravanan S. M. Rout Sagar A. Khulape	2014-18	<b>ICAR-DFMD &amp; PIADC, USA</b> collaborative project
16.	Evaluation of selected foot and mouth disease virus strains for their potential as vaccine	B P Sreenivasa (IVRI)	J K Biswal Saravanan S R Ranjan A Sanyal (IVRI)	2016-18	<b>ICAR-DFMD &amp; ICAR-IVRI</b> collaborative project

# Significant Achievements During XII<sup>th</sup> Plan

## 12.1 FMD diagnosis and surveillance in the country

- 1281 suspected FMD cases were investigated and diagnosed as caused by serotypes O (n=1186, 92.6%), A (n=30, 2.3%) and Asia1 (n=65, 5.1%). Serotype O FMD virus dominated the field scenario in the country during all the years. There was absence serotype A during 2014-15 and 2016-17, and serotype Asia1 during 2016-17. Circulation and prevalence of FMD virus serotype A and Asia1 is gradually decreasing since 2004-05, along with increased circulation of serotype O virus.
- Under **National FMD serosurveillance programme**, 2,86,008 bovine serum samples collected at random from all over the country were subjected to 3AB3 NSP ELISA (DIVA), and overall reduction in NSP prevalence over the period was observed and during 2017-18, 21.2% cattle and buffalo samples revealed NSP-antibodies suggesting exposure to FMD virus (DIVA positive). Serosurveillance of FMD in **sheep and goat** population revealed ~18% DIVA positivity. During 1995, 91% of the bovine serum samples (2175), 89% of the ovine serum samples (145) and 59% of the caprine serum samples (70) were DIVA positive indicating higher circulation of virus at that time. With the implementation of FMDCP since 2003-04, DIVA positivity in bovine has dropped to 21.2% in 2017-18 and in ovine and caprine has dropped to (~18%). Gradual clearance of virus has resulted in gradual decrease in virus positivity in the country. This speaks of success of FMDCP.
- A total of 291 FMD virus isolates (O-213, A-44, and Asia1-34) isolated in BHK-21 cell system were added to the ever growing **national repository of FMD virus** during 2012-17.

## 12.2 Antigenic characterization and vaccine matching

- A total of 289 field virus isolates recovered during 2012-17 ( O-207, A-32 and Asia1-50) were antigenically characterized. The field situation suggested **emergence of antigenically divergent strains** in serotype A, while majority of isolates in serotype O and Asia 1 were found to be antigenically related to their respective vaccine strains.
- To circumvent emergence of antigenically divergent VP3<sup>59</sup>-deletion group strains in serotype A, **an alternate vaccine candidate strain** (A IND 27/2011) has been identified for replacement of existing vaccine strain A IND 40/2000 to maintain the vaccine efficacy. The study on vaccine worth attributes of the candidate strain is currently underway.

## 12.3 Genetic characterization and phylogeny

- Capsid coding region (P1/VP1) sequences for 367 FMD virus strains were deduced and were added to the sequence database for Indian FMD viruses. Analysis of these data led to **many important phylogenetic inferences**.
- The **serotype O Ind2001 lineage** nearly **outcompeted PanAsia lineage**. Emergence of different sub-lineages (Ind2001d and Ind2001e) within Ind2001 was observed.
- As per evolutionary dynamics, the **evolution of Ind2001 lineage deviates from the strict molecular clock** and characterized by periodic emergence and re-emergence of Ind2001 and PanAsia lineages.
- In case of **serotype A, genotype 18** is exclusively present in India within which **VP3<sup>59</sup>-deletion** group exclusively dominated the field outbreaks in the recent years.

- In serotype **Asia 1**, **lineage C** continued to dominate since the year 2005.
- Three decades-long (1977-2013) evolutionary trend of the capsid coding (P1) region of foot-and-mouth disease virus (FMDV) serotype A isolated in India indicated, as per Bayesian skyline plots, a **sharp decline in the effective number of infections after 2008, which might be a result of mass vaccination or inherent loss of virus fitness.**
- Diversity in the Capsid coding region of lineage C serotype Asia1 FMD virus was due to **Recombination events in the structural protein coding region.**
- **Recombinant FMDV capsid polypeptide** of serotype O FMD virus was developed and was found suitable as antigen for use in different diagnostic methods. This will dispense with use of whole virus inactivated antigen when India enters Stage- 4 of the progressive control pathway (PCP) for control of FMD.
- **Diagnosis of FMD by RNA transfection was optimized.** A significantly higher rate of virus isolation from clinical materials regardless of their detection status in ELISA or multiplex PCR was achieved by this method. Virus could be recovered from the clinical samples stored at higher temperatures and pH for up to five weeks time that break down viral capsid. This technique is very much suitable even for the clinical materials dispatched under high ambient temperature.

## 12.4 Research for Development

### (i) Newer diagnostic methods

- A **boiling-based RT-mPCR assay** was developed for direct detection of FMD Virus (FMDV) genome in tongue epithelium samples without the requirement for RNA purification. This saved time in giving diagnosis.
- Use of absorbent cards for clinical virus material collection followed by RNA transfection **increased live virus rescue by 20%** over conventional method of virus isolation in cell culture (56%). This virus isolation method has been developed in a time when there is paucity in quantity of clinical tissue material available for detailed diagnosis due to drop in severity of clinical sickness on account of regular FMD vaccination, and in every case causative virus has to be isolated.
- Genome diagnostic methods (mPCR and RT LAMP) were applied successfully to detect **FMD virus in milk** during and after the subset of FMD. Detection limit of mPCR and RTLAMP assay was  $10^{2.7}$  and  $10^{1.7}$  TCID<sub>50</sub>/ml, respectively. **Milk is a potential media for transport of FMD virus to distant places.**
- 3A non-structural protein (NSP) based **DIVA ELISA** was developed. The r3A I-ELISA could be useful as a screening or confirmatory assay in the sero-surveillance of FMD in India irrespective of extensive bi-annual vaccination.
- **Indirect ELISA based on FMDV NSP 3B was developed.** Considering the extent of variation observed in the serological response to individual NSPs in the infected animals, screening of samples in r3B I-ELISA with higher specificity and in r3AB3 I-ELISA with higher sensitivity as an integrated system could be considered as a reasonable option in India to increase the confidence of detecting infected herds.
- **Truncated recombinant 2C-based indirect ELISA for FMD sero-surveillance was optimized.** The 2C<sub>t</sub>-ELISA kit developed and validated will be an adjunct to the r3AB<sub>3</sub>-ELISA kit being currently used in India for increasing sensitivity of detection in low FMD prevalence zones under FMD control programme.
- **2B based indirect ELISA for FMD serosurveillance was evaluated.** As the performance of the recently developed recombinant Δ2B I-ELISA is comparable to the r3AB3 I-ELISA, the Δ2B assay has the potential to be used either as a screening or confirmatory assay in conjunction with the r3AB3 I-ELISA.
- **Serodiagnostic strategy for detecting**



**antibodies to FMDV based on recombinant capsid polyprotein was designed.** This demonstrates that the recombinant capsid polyprotein-based ELISA has the potential to be an easy-to-perform, safe alternative to the conventional LPBE/SPCE for the quantitative detection of antibodies to FMDV serotype O. This will dispense with use of whole virus inactivated antigen. The study is in progress on the serotype A and Asia 1.

## (ii) Designer virus construction for advantage

- FMD virus serotype O vaccine strain with enhanced **thermo-stability** was constructed using reverse genetic approach to open way for thermostable FMD vaccine. The crucial amino acid residues those are located at, or very close to, the inter-subunit interfaces of the FMD viral capsid were changed by **site-directed mutagenesis**.
- **Custom made Chimeric FMDV cDNA clones** were developed using **mega primer-mediated capsid swapping**. The chimeric viruses were similar in all parameters to the parents. This will help in faster designing of viruses to circumvent antigenic divergence and vaccine mismatch.
- A **negative marker FMDV serotype O virus** (vaccine strain O IND R2/1975), containing dual deletions of amino acid residues 93-143 and 10-37 in the non-structural proteins 3A and 3B through **reverse genetics** was constructed. In addition, an indirect ELISA (I-ELISA) **targeted to the deleted 3AB NSP region** (truncated 3AB) was developed and evaluated which could be used as a companion differential diagnostic assay. This paves way for development of DIVA compatible FMD vaccine that can be used in NSP antibody free animal populations when the country reaches stage 4 of PCP for control of FMD.

## (iii) New methodology

- An efficient system for **purification and concentration of FMDV particles**, was

developed by designing a **His<sub>6</sub>-tagged virus** that helped in one-step purification by metal affinity chromatography. The tagged virus was functionally the same as that of the untagged virus. The process has application during manufacture of FMD vaccine to make NSP free FMD vaccines

- Improved adaptability of FMDV in BHK-21 cells for virus isolation was achieved by **introduction of a positive charged amino acid residue** at position VP2 131 Through **site-directed mutagenesis on the cDNA clone**. This process can help in enhancing infectivity of BHK21 cells for higher FMD virus yield during vaccine manufacture.

## 12.5 Seromonitoring

- Technical/laboratory and logistic support to the **FMD control programme (FMDCP)** being run by DAHD&F, Govt of India for **post-vaccination sero-monitoring** was extended. Under this programme, a total of 10,02,437 serum samples have been tested till 2017-18 and results with interpretation have been submitted to DAHD&F. The best success story of FMDCP is Delhi followed by Punjab, AP, TS and Gujarat. The other states under FMDCP have to improve in implementing regular vaccination.
- **Impact assessment of bi-annual FMD vaccination** was performed. The baseline data for district level herd immunity was generated. It was observed that herd immunity is gradually and progressively building up with regular vaccination in some areas under FMD control programme. Analysis of the antibody kinetics revealed tentative duration of the protective herd immunity (median antibody titer  $\geq \log_{10}$  1.8) against the three serotypes of FMDV up to 160-180 days post vaccination, leaving **an infection window of about 20 days** in some population that pose risk of appearance of sporadic incidences/case. Therefore it is essentially required that bi-annual vaccination continues till and after last case of FMD, and uniformity in time and density of vaccination has to be implemented.

## 12.6 FMD Ecology

- The duration of the **FMD virus carrier state**/persistent infection in cattle and buffalo was investigated. The **mean extinction time** of the carrier state was  $13.1 \pm 0.2$  months, with extinction having occurred significantly **faster amongst adult dairy cattle** compared to younger animals. These data provide novel insights into viral and host factors associated with the FMDV carrier state under natural conditions. The proportion of virus isolation positive FMD-carrier status has been more in buffalo as compared to the cattle.
- FMDV associated **abortion and vertical transmission** following acute Infection in cattle under natural Conditions was observed and established. Gross pathological findings included blood-tinged peritoneal and pleural effusions and myocarditis. Heart of dead calves had mild to moderate degeneration and necrosis of the myocardium with moderate infiltration of mixed inflammatory cells. Localization of FMDV antigen was demonstrated in lungs and soft palate of dead calves by immunemicroscopy.

## 12.7 Production and supply of diagnostics

- Diagnostic Kits and reagents for FMDV detection and diagnosis, surveillance and

seromonitoring were produced, optimized, evaluated and supplied to different units/centres of the AICRP on FMD network, vaccine manufacturers and universities. 3AB3 DIVA kit for 3,97,760 samples, LPBE/SPCE kit for 8,51,970 samples and FMDV serotyping ELISA kit for 5,45,00 samples were supplied to the regional FMD laboratories and others. **This made the country self-sufficient in FMD diagnostics and companion diagnostics for the FMDCP.**

- 12.8: Training on FMD diagnosis
- A trained work force for undertaking FMD diagnosis and seromonitoring was created in the country as well as in the SAARC region. A total of 33 training programmes for researchers both within the country and in the SAARC region were organized. A total of 87 researchers from different regional and collaborative centres under AICRP on FMD, India were trained.

### Training Organized

During 2017-18, one training Programme on DIVA-ELISA was organized during 14-19, November 2017, in which scientists of AICRP on FMD participated.

# Publications, Awards and Honours

## 13.1 Research Papers (Total IF: 18.698, NAAS rating: 82.2)

### International

1. Biswal JK, Subramaniam S, Ranjan R, Pattnaik B (2017) Uncleaved 2A-peptide of foot-and-mouth disease virus can display foreign epitope-tag at the virion surface. **Infect Genet Evol** (Elsevier) 54:324-329 (Impact factor:2.885, NAAS rating:8.59)
2. Bhatt M, Mohapatra JK, Pandey LK, Mohanty NN, Das B, Prusty BR, Pattnaik B (2017). Mutational analysis of foot and mouth disease virus nonstructural polyprotein 3AB-coding region to design a negative marker virus. **Virus Res** (Elsevier) 243:36-43. (Impact factor: 2.628, NAAS rating: 8.53)
3. Subramaniam S, Das B, Biswal JK, Ranjan R, Pattnaik B (2017) Antigenic variability of foot-and-mouth disease virus serotype O during serial cytolytic passage. **Virus Genes** (Springer). 3(6):931-934 (Impact factor:1.431, NAAS rating:7.29)
4. Ranjan R, Biswal JK, Subramaniam S, Dash BB, Singh KP, Arzt J, Rodriguez LL, Pattnaik B (2018) Evidence of subclinical foot-and-mouth disease virus infection in young calves born from clinically recovered cow under natural condition. **Trop Anim Health Prod** (Springer). doi: 10.1007/s11250-018-1518-6 (Impact factor:0.912, NAAS rating:6.87)
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6. Hayer SS, VanderWaal K, Ranjan R, Biswal JK, Subramaniam S, Mohapatra JK, Sharma GK, Rout M, Dash BB, Das B, Prusty BR, Sharma AK, Stenfeldt C, Perez A, Delgado AH, Sharma MK, Rodriguez LL, Pattnaik B, Arzt J (2017) Foot-and-mouth disease virus transmission dynamics and persistence in a herd of vaccinated dairy cattle in India. **Transbound Emerg Dis**. doi: 10.1111/tbed.12774 (Impact factor: 3.585, NAAS rating: 8.71)
7. Dash L, Subramaniam S, Khulape SA, Prusty BR, Pargai K, Narnaware SD, Patil NV, Pattnaik B (2018) Development and utilization of VHH antibodies derived from Camelus Dromedarius against Foot and-Mouth Disease Virus. **Animal Biotechnology** (Taylor & Francis). doi.org/10.1080/10495398.2018.1433191 (Impact factor:0.75, NAAS rating: 6.69)
8. Sreenivasa BP, Mohapatra JK, Pauszek SJ, Koster M, Dhanya VC, Tamil Selvan RP, Hosamani M, Saravanan P, Basagoudanavar SH, de Los Santos T, Venkataramanan R, Rodriguez LL, Grubman MJ (2017). Recombinant human adenovirus-5 expressing capsid proteins of Indian vaccine strains of foot-and-mouth disease virus elicits effective antibody response in cattle. **Vet Microbiol**. doi: 10.1016/j.vetmic.2017.03.019 (Impact factor: 2.628, NAAS rating: 8.56)

### National

1. Rout M, Subramaniam S, Mohapatra JK, Dash BB, Pattnaik B (2017) Investigation of foot-and mouth disease outbreak in a pig farm at Kollam district of Kerala, India. **Indian J. Anim. Res** (ARCC Journals) DOI: https://doi.org/10.18805/ijar.B-3071 (Impact factor: 0.147 NAAS rating: 6.09)
2. Rout M, Subramaniam S, Mohapatra JK, Sanyal A, Dash BB, Pattnaik B (2017) Phylogenetic characterization of foot-and-mouth disease

- virus recovered from mithuns and yaks in India. **Indian J. Anim. Res** (ARCC Journals) DOI:10.18805/ijar.v0iOF.9138 (Impact factor: 0.147 NAAS rating: 6.09)
3. Rout M, Subramaniam S, Mohapatra JK, Pattnaik B (2017) Molecular epidemiologic investigation of foot-and-mouth disease in pig population of India. **Indian J. Anim. Res** (ARCC Journals) DOI: 10.18805/ijar.v0iOF.7809 (Impact factor: 0.147 NAAS rating: 6.09)
  4. Audarya SD, Pattnaik B, Sanyal A, Mohapatra JK (2017) Toll like receptor 7 messenger RNA expression levels in dairy bovines in an outbreak of Foot-and-Mouth disease. **Buffalo Bulletin**. 36:3 489-495 ( NAAS rating: 6.07)
- ### 13.2 Presentations in Conferences/Symposia/Seminars/Other fora
1. Dr Khulape SA delivered an oral talk at Genomics Analysis and Technology Conference (GATC) seminar series on Quasispecies reconstruction of type Asia1 Foot and Mouth Disease virus by VP1 hyper-variable gene C' terminal region amplicons based approach organized at National Institute of Science Education and Research (NISER), Bhubaneswar during September 8<sup>th</sup> -9<sup>th</sup>, 2017.
  2. Ranjan R, Biswal JK, Subramaniam S, Pattnaik B (2017). Persistence of foot-and-mouth disease virus in cattle and buffalo. National Seminar on "Opportunities and Challenges of Transnational Research in the Frontier Areas of Animal Biotechnology", from 22- 23 September 2017 at C.V.Sc. & A.H., OUAT, Bhubaneswar, Odisha. Pp.- 62-65. (Lead Presentation)
  3. Biswal JK, Ranjan R, Subramaniam S, Pattnaik B (2017). Reverse genetics approaches for the development of next generation vaccines against foot-and-mouth disease. National Seminar on "Opportunities and Challenges of Transnational Research in the Frontier Areas of Animal Biotechnology", from 22- 23 September 2017 at CVSc & AH, OUAT, Bhubaneswar, Odisha. Pp.- 65 (Lead Presentation).
  4. Biswal JK, Ranjan R, Subramaniam S, Pattnaik B (2017). Marker vaccine potential of foot-and-mouth disease virus displaying the exogenous tetanus toxoid epitope-tag at the surface. National Seminar on "Opportunities and Challenges of Transnational Research in the Frontier Areas of Animal Biotechnology", from 22- 23 September 2017 at CVSc & AH, OUAT, Bhubaneswar, Odisha. Pp.-70. (Oral Presentation).
  5. Biswal J K, Rajeev R, Subramaniam S, Das B, Rodriguez L; Arzt J and Pattnaik B (2017). Foot-and-Mouth Disease Virus expressing chimeric capsid protein: A tool for delineation of new antigenic sites and vaccine strain selection. Global Foot-and-Mouth Disease Research Alliance (GFRA) 2017, Scientific Meeting in Incheon, South Korea, 25- 27 October 2017 Pp- 44 (Poster Presentation).
  6. Ranjan R, Biswal J K, Subramaniam S, Biswajit D, Rodriguez L; Arzt J and Pattnaik B (2017). FMD virus ecology and its landscape epidemiology in cattle and buffalo under natural condition in India. Global Foot-and-Mouth Disease Research Alliance (GFRA) 2017, Scientific Meeting in Incheon, South Korea, 25- 27 October 2017. Pp-15 (Poster Presentation).
  7. Ranjan R, Biswal J K, Subramaniam S, Singh KP and Pattnaik B (2017). Foot and mouth disease virus: Abortion and vertical transmission in cattle under natural condition. International Conference on "Emerging Horizons in Diagnosis of Animal and Poultry Disease-Towards Sustainable Production in Asia Countries" under Asian Veterinary Pathology Congress-2017 at Department of Veterinary Pathology, Veterinary College, Hebbal, Bengaluru, Karnataka, India organized by the Asian Society of Veterinary Pathologists, 9-11 November 2017. Pp- 55 (Oral Presentation).
  8. Ranjan R, Biswal J K, Subramaniam S, Singh KP and Pattnaik B (2017). Foot and mouth disease virus ecology in cattle and buffalo under natural condition in India. International Conference on "Emerging Horizons in Diagnosis of Animal and Poultry Disease-Towards Sustainable Production in Asia Countries" under Asian Veterinary Pathology Congress-2017 at Department of



Veterinary Pathology, Veterinary College, Hebbal, Bengaluru, Karnataka, India organized by the Asian Society of Veterinary Pathologists, 9-11 November 2017. Pp- 69-70 (Poster Presentation).

9. Subramaniam S, Das B, Dahiya SS, Khulape SA, Biswal JK, Ranjan R, Pattnaik B (2018) Genetic and antigenic analysis of FMD virus serotype O collected during 2016-17 from India. XXXI Annual convention of Indian Association of Veterinary Microbiologists, Immunologists and Specialists in Infectious Diseases and National symposium on Innovations in animal health – current challenges and future prospective. 29th to 31st January, 2018. Department of Veterinary Microbiology, College of Veterinary Science. Sri Venkateswara Veterinary University, Tirupati – 517 502, AP, India

### 13.3 Awards

1. “ASVP President’s Poster Award” to Dr. Rajeev Ranjan and Associates (J.K. Biswal, S. Subramaniam, K.P. Singh, B. Pattnaik )for best poster on the topic entitled “*Foot and Mouth Disease virus ecology in Cattle and Buffalo under natural condition in India*” during International Conference on “*Emerging Horizons in Diagnosis of Animal and Poultry Disease-Towards Sustainable Production in Asia Countries*” under Asian Veterinary Pathology Congress-2017 at Department of Veterinary Pathology, Veterinary College, Hebbal, Bengaluru, Karnataka, India organized by the Asian Society of Veterinary Pathologists, 9-11 November 2017.
2. “IAVP-Best Poster Presentation Award-2017” to Drs. Rajeev Ranjan, J.K. Biswal, S. Subramaniam, K.P. Singh, B. Pattnaik for the Poster entitled “*Foot and Mouth Disease virus ecology in Cattle and Buffalo under natural condition in India*” ICAR-International Centre for Foot and Mouth Disease, Arugul, Bhubaneswar during Asian Veterinary Pathology Conference held at Veterinary College, Hebbal, Bengaluru, Karnataka, India organized by the Asian Society of Veterinary Pathologists, 9-11 November 2017.
3. *Rashtriya Gaurav Award Certificate of Excellence* presented to Dr. Rajeev Ranjan for meritorious services, outstanding performance and remarkable role by Lt. Gen Krishna Mohan Seth (Retd), Former Governor of Chhattisgarh, Madhya Pradesh and Tripura at a seminar on Economic Growth and National Integration organized by India International Friendship Society at New Delhi on 26<sup>th</sup> March 2018.
4. Dr Biswal JK was awarded for best talk from the endemic region at GFRA) 2017, Scientific Meeting in Incheon, South Korea, 25- 27 October 2017 Name of the
5. “IAVP-Gang-Mana Sharma Award for Best Full Paper and Case Report on Pack Animals - 2016” for the paper entitled ‘Evidence of foot-and-mouth disease virus infection in yaks reared in a farm of Arunachal Pradesh’ authored by M. Rout, J. Doley, S. Maiti, A.K. Bera, N. Chatterjee, D. Bhattacharya and J.K. Mohapatra, published in Indian Journal of Veterinary Pathology, 2016, 40(3): 284-286. Asian Veterinary Pathology Congress, XXXIV Annual Conference of Indian Association of Veterinary Pathologists, held at Veterinary College, Hebbal, Bengaluru, India during 9-11 November’ 2017.

## Training undergone by Scientist/staff

1. Dr Khulape SA attended 21 days CAFT program “Advanced Statistical Techniques in Biometrics” at Indian Agriculture Statistics Research Institute, New Delhi from August 10<sup>th</sup> -30<sup>th</sup>, 2017.
2. Dr Khulape SA attended CSIR- Integrated Skill Development Program on “Mass Spectrometry and Proteomics” at CSIR- National Chemical Laboratory, Pune from November 1<sup>st</sup>-17<sup>th</sup>, 2017.
3. Dr Dahiya SS participated in the Training Programme in Engineering Mammalian Cells with CRISPR Tools at CCMB, Hyderabad from 06.02.2018 to 17.02.2018.
4. Mr Kumar Rishiraj, Administrative Officer, attended training on “OSP on GFR 2017” at ISTM, New Delhi.
5. Mr Kumar Rishiraj, Administrative Officer, attended training on “National Level training on Procurement and PFMS” at ICAR-CPRI, Shimla.

- Dr. Sahoo AP, Dr Khulape SA and Mr Kumar M participated in Kisan Mela 2018 (October 7<sup>th</sup>, 2017) at ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan, Hawalbagh.
- Dr. Rout M, Dr. Sahoo AP, Dr. Dahiya SS, Mr Tamta SL and Mr. Kumar M participated in the Vigilance and FMD awareness camps were organized at Government Inter College, Mukteswar, Government Higher Secondary School, Reetha, Shiv Narayan Singh Negi Government Inter College, Nathuwakhan, Kishan Singh Mehta Government Inter College, Supi and Saraswati Sishu Vidya Mandir, Gonguwachoud.
- Dr. Khulape SA participated as Expert Member for Animal Judging competition at Kisan Mela 2018 (February 28<sup>th</sup>, 2018), Indian Veterinary Research Institute, Mukteshwar campus.
- Dr. Rout M, Dr. Khulape S, Mr Tamta SL and Mr Kumar M, participated in Kisan Mela 2018 (February 28<sup>th</sup>, 2018), Indian Veterinary Research Institute, Mukteshwar campus.
- Dr. Rout M, Dr Khulape SA, Mr Tamta SL and Mr. Kumar M participated in Krishi Unnati Mela 2018 at ICAR- Indian Agricultural Research Institute from March 16<sup>th</sup> -19<sup>th</sup>, 2018.
- Dr. Rout M, Dr. Dahiya SS and Mr. Kumar M, participated in the Kisan Mela at ICAR-VPKAS Experimental farm, Hawalbagh, Almora on 23.03.2018.

## Meeting/Conference/Symposium Attended by Staff/Scientist

1. Dr Subramaniam S participated in Dairy Asia; For health and prosperity Domestic stakeholder meeting held at NDDDB, Anand , Gujarat on 15-05-17
2. Dr Subramaniam S participated in participated in the meeting to finalize technical specification and tender conditions for procurement of vaccine on 31-05-17 under the chairmanship of Director, AH & VS, Karnataka.
3. Dr Subramaniam S participated in the meeting to discuss about outbreak situation in the state of Karnataka on 15-06-17 under the chairmanship of Director, AH & VS, Karnataka at office of Joint Director (epi) AH & VS
4. Dr Mohapatra JK and Dr Subramaniam S participated in the technical committee meeting to investigate the FMD incidences in the state of Karnataka on 14-08-2017 under the chairmanship of Director, NIVEDI, Bengaluru.
5. Dr Khulape SA participated in Genomics Analysis and Technology Conference (GATC) seminar series at National Institute of Science Education and Research (NISER), Bhubaneswar during September 8<sup>th</sup> -9<sup>th</sup>, 2017.
6. Dr. Ranjan R participated in National Seminar on “Opportunities and Challenges of Transnational Research in the Frontier Areas of Animal Biotechnology”, from 22<sup>nd</sup> to 23<sup>rd</sup> September 2017 at CVSc & AH, OUAT, Bhubaneswar, Odisha.
7. Dr. Ranjan R participated in Global Foot-and-Mouth Disease Research Alliance (GFRA) 2017, Scientific Meeting in Incheon, South Korea, 25-27 October 2017.
8. Dr Biswal JK participated in Global Foot-and-Mouth Disease Research Alliance (GFRA) 2017, Scientific Meeting in Incheon, South Korea, 25-27 October 2017.
9. Dr. Ranjan R participated in International Conference on “Emerging Horizons in Diagnosis of Animal and Poultry Disease-Towards Sustainable Production in Asia Countries” under Asian Veterinary Pathology Congress-2017 at Department of Veterinary Pathology, Veterinary College, Hebbal, Bengaluru, Karnataka, India organized by the Asian Society of Veterinary Pathologists, 9-11 November 2017
10. Dr Subramaniam S participated in International seminar on “Emerging horizons in diagnosis of animal and poultry diseases: towards sustainable production in Asian countries” 34<sup>th</sup> Annual Conference of Indian Association of Veterinary Pathologists. Veterinary College, Hebbal, Bengaluru, 560024, Karnataka, India. 9-11, November, 2017
11. Dr Rout M participated in International seminar on “Emerging horizons in diagnosis of animal and poultry diseases: towards sustainable production in Asian countries” 34<sup>th</sup> Annual Conference of Indian Association of Veterinary Pathologists. Veterinary College, Hebbal, Bengaluru, 560024, Karnataka, India. 9-11, November, 2017
12. Dr. Mallick S participated in XXVI annual conference of society of animal physiologists of India (SAPI) at Bidar veterinary college, Karnataka, from 21-22 December 2017
13. Dr Subramaniam S participated in participated in XXXI Annual convention of Indian Association of Veterinary Microbiologists, Immunologists and Specialists in Infectious Diseases and National symposium on Innovations in animal health – current challenges and future prospective. 29-31<sup>st</sup> January, 2018. Department of Veterinary Microbiology, College of Veterinary Science. Sri Venkateswara Veterinary University, Tirupati – 517 502, AP, India
14. Dr Subramaniam S participated in Participated in the meeting to discuss the sero-monitoring results under FMD-CP for the four DFZ states at Krishi Bhawan, New Delhi on 12<sup>th</sup> February, 2018.

# Establishment of state-of-the-art BSL-3Ag high containment facility at International Centre for FMD (ICFMD), Jatani, Odisha

Since, FMD is one of the most contagious diseases known, and for disease control to be effective there must be rapid and accurate diagnosis. This can only be achieved by competent staff in a specialised, high containment disease-secure laboratory, which must not itself constitute a risk for virus transmission. The establishment of ICFMD with BSL-3Ag high-containment facility by ICAR would cater the need of the country for safe handling of FMD virus as per the international norms. Owing to the transboundary nature of the disease, establishment of this high-containment laboratory would help in analysing exotic FMD virus strains circulating elsewhere in the world in order to develop preparedness in terms of diagnostics and vaccines in the event of their incursion into the country. Therefore, establishment of ICFMD with high containment facility is an essential component of FMD control strategies.

*The salient features of the ICFMD BSL-3Ag facility are:*

- State-of-the-art Biosafety laboratory with three levels of containment.
- Primary containment with highly reliable biosafety cabinets.
- Secondary containment with air-tight pre-engineered modular partitioned insulated chambers with controlled environment through highly reliable HVAC and IBMS (Integrated Building Management System).
- Tertiary containment with air-tight concrete containment building constructed with special features such as (a) self-compacting concrete structure having low shrinkage properties with high precision, (b) Post tensioning of concrete to minimize the shrinkage cracks, (c) the containment envelop is provided with crack-bridging epoxy coating to achieve air-tightness.

- The total floor area of ICFMD is 15796.11 SQM which comprises of various facilities as follow

- ◇ BSL2 Area: 2303 SQM
- ◇ BSL-3Ag Area: 4233.94 SQM
- ◇ Effluent Decontamination System (EDS) Area: 614.28 SQM
- ◇ Non-BSL Area: 8644.89 SQM

Heating, Ventilation and Air-conditioning (HVAC) is the technology of indoor and vehicular environmental comfort. Its goal is to provide human comfort and acceptable indoor air quality. HVAC facilities available at ICFMD are given below

Sl No	DESCRIPTION	DETAILS
1	Pressures	
1 a	Pressures in BSL-3Ag Areas	-10 Pa to -60Pa
1b	Pressures in BSL2 Areas	+5 Pa to 50 Pa
1c	Pressures in EDS Areas	-5Pa to -40Pa
2	Air Handling Units	36 Nos
3	Exhaust Units	13 Nos
4	Imported Bag-in-Bag-out HEPA Filter Units	6 Nos
5	Indigenous Bag-in-Bag-out HEPA Filter Units	12 Nos
6	Terminal HEPA Filter Modules for Supply Air	146 Nos

The Main Laboratory Building (MLB) of ICFMD is designed with following specialities

- Laboratory interior are designed with pre-engineered, pre-fabricated insulated clean room modular panels.
- Highly reliable HVAC and IBMS system to maintain controlled environment and secured biometric access system. Highly efficient H14 filters with 99.99% efficiency for filtering of

virus-contaminated air and an innovative heat recovery system.

- Highly reliable Effluent decontamination plant and secondary effluent treatment plant (ETP).
- High precision decontamination Autoclaves, formalin Airlocks, Pass boxes, Dunk tanks, air tight doors and vision panels.
- Highly reliable and energy efficient Chillers and Air Compressors.
- Efficient air tight penetrations for cables and pipes in the containment areas.

***Mandate of International Centre for FMD (ICFMD)***

- To act as apex laboratory in India and SAARC region relating to referral services on FMD epidemiology.
- To act as National Reference Laboratory (NRL) pertaining to FMDV characterization and to

recommend appropriate candidate vaccine strains for incorporating in the vaccine.

- To monitor relevance of utilization of such vaccine strains in changing epidemiological situation.
- To maintain repository of FMD virus, serum and other biological.
- To function as knowledge bank relating to all information pertaining to FMD for country, region and the globe.
- To maintain and monitor the quality of diagnostics and the techniques employed for FMD virus characterizations in India and SAARC countries, and to validate newer techniques and reagents.
- To provide consultancy service and training facilities for use by the agencies from India and abroad.

**Main entrance for ICAR-DFMD-ICFMD, Arugul Campus**



# Reports and Recommendations

## 18.1 Proceedings of the 8<sup>th</sup> meeting of the Research Advisory Committee (RAC) of ICAR- Directorate of Foot and Mouth Disease (DFMD) held on 18 January 2018 at ICFMD, Arugul, Bhubaneswar

The eighth meeting of the RAC of ICAR-DFMD was held at the International Center for FMD (ICFMD), Arugul, Bhubaneswar on 18<sup>th</sup> January 2018 under the Chairmanship of **Dr. R.N.S. Gowda**, Former Vice Chancellor, KVAFSU, Bengaluru. The following members were present.

1. **Dr. M.V. Subbarao**, Member, Former Dean, SVU, Hyderabad
2. **Dr. Nem Singh**, Member, Former Joint Director (Research), IVRI
3. **Dr. B.C. Kar**, Member, Former Professor, Orissa Veterinary College
4. **Dr. B. Pattnaik**, Project Director, ICAR-DFMD
5. **Shri Sumit Lakhota**, Farmer Member, Kashipur, Uttarakhand
6. **Shri Khirod Satapathy**, Farmer Member, Khordha, Odisha
7. **Dr. Saravanan S**, Senior Scientist and I/C PME, ICAR-DFMD
8. **Dr. R. Ranjan**, Scientist (SS), ICAR-DFMD
9. **Dr. J.K. Biswal**, Scientist (SS), ICAR-DFMD
10. **Dr. A.P. Sahoo**, Scientist (SS), ICAR-DFMD
11. **Dr. (Ms) S.R. Mallick**, Scientist, ICAR-DFMD
12. **Dr. R. Chandrashekar**, Former Vice chancellor, Rajiv Gandhi University of Health Sciences, Bengaluru - Invitee
13. **Dr. B. B. Dash**, Consultant, ICFMD, Bhubaneswar - Invitee

**Dr. B. Pattnaik** welcomed the Chairman and members of the RAC. The ICAR Sangeet was played before start of the meeting.

**Dr. R.N.S. Gowda**, Chairman, RAC, in his opening remark appreciated the enormous effort put in to establish ICFMD, a state-of-the-art BSL3-Ag facility at Bhubaneswar to cater the need of India and other SAARC Nations. He expressed happiness that the ICFMD high containment laboratory facility is a landmark in the field of veterinary science, and one of the best in the field of FMD virus research in the line of Plum Island Animal Disease Center, USA; The Pirbright Institute, UK; Friedrich Loeffler Institute (FLI), Germany and Institute of Virology and Immunology (IVI), Switzerland. The effort of **Dr. B. Pattnaik**, Director, ICAR-DFMD to bring into existence the state-of-the-art high containment laboratory in India was appreciated by the Chairman. Further, he emphasized the need for control and subsequent eradication of FMD from India and neighboring SAARC countries by creating disease free zones (DFZs) in the country as per OIE guidelines. He felt that though India is a leader in several areas of livestock industry in terms of animal population and production, the country is unable to utilize its export potential because of trade embargo due to prevalence of FMD.

The Action Taken Report (ATR) on the recommendation of seventh meeting of the RAC was presented by **Dr Saravanan S**. Further, he presented the overall achievement made during the years 2015-16 and 2016-17. It was diagnosed that serotype O virus dominate the FMD scenario in the country followed by a few incidences of serotypes Asia1 and A. Overall reduction in the incidence of FMD was evident in all the regions of the county except during the year 2013. Serotype Asia1 virus only prevailed in the Eastern part of the county, which may be due to probable interstate transboundary movement of the virus in the eastern zone. A total of 125 FMD

virus field isolates were isolated, characterised and added to the National FMD virus repository during the period. The institute also participated in seromonitoring under FMD control programme (FMDCP) run by DAHD&F, Government of India. Reduction in the number of nonstructural protein (NSP) antibody bearing animals and progressive built up of herd immunity indicate successful control of FMD in the country through regular vaccination. Due to the emergence of antigenic variants in serotype A, an alternate candidate vaccine strain has been selected based on series of studies and is ready for use. The institute standardized and supplied three major diagnostic kits (SP-ELISA for estimation of structural antibodies, DIVA-ELISA for the estimation of NSP antibodies and S-ELISA for virus serotype identification) to regional and collaborating centers of AICRP on FMD located across the country and also to the SAARC nations to maintain uniformity in the results accrued. All the research projects undertaken during 2015-16 and 2016-17 were completed except one collaborative project that will be completed by September 2018. The major thematic areas of research projects of the Institute included surveillance, epidemiology, diagnosis and virus characterizations, vaccine matching, seromonitoring, diagnostics and vaccines, pathogenesis, virus ecology and disease economics etc.

The effort made by the scientists of the institute for bringing up excellent achievements during the last two years was appreciated by the Chairman and the members. The Chairman congratulated the Director and the scientists for their endeavor in planning and execution of the research projects to support control of FMD in the country. The Chairman further appreciation that the major thematic areas have been addressed under the research projects.

**Dr. B. Pattnaik** informed that the genetic and antigenic volatility of FMD virus (FMDV) is due to its quasispecies nature where any given sample of FMDV will have copies of related but non-identical RNA genome, and therefore real time genetic and antigenic characterization of field isolates in order to identify emergence of variants in the field is essential. Through these approaches, change in

vaccine strains of serotype A has been advised periodically. He further, informed that DFZ for FMD will be created 20 km radius around ICFMD, Bhubaneswar as per the International norm. Further, indicator animals will be housed at the facility as a biosafety and biosecurity measure.

**Dr. R.N.S. Gowda** emphasized the importance of understanding the basics of FMD virus pathology and immunology so that necessary intervention mechanisms can be developed for the control of FMD. Further, he said that minimum vaccine dose should be increased to at least 12 PD50 and pigs also should be vaccinated as they are amplifier of the virus. The Chairman stressed for early establishment of the pending BSL-3Ag high containment Animal Experimentation Facility (AEF) to meet the mandate of the ICFMD and complete its functionality.

**Dr. M.V. Subbarao** suggested that sampling frame for seromonitoring and serosurveillance should be decided based on animal density rather than district wise sampling.

**Dr. B.C. Kar** informed that people of certain areas in the state of Odisha do not allow their animals to be vaccinated against FMD as they consider the cow as Goddess. In many states some farmers believe that milk yield may drop following FMD vaccination. This kind of taboo need to be eliminated from farmers' mind and motivate to vaccinate all the eligible animals through FMD awareness programs. He emphasized to engage a biostatistics scientist/consultant for proper management of the data generated under the epidemiological studies of FMD in the country over the years.

**Dr. R. Chandrashekar** emphasized that one epidemiologist and biostatistician should be engaged for better assessment of data. Further he inquired about the virus ecology with respect to prevalence of O/ME-SA/Ind2001 lineage in India, North Africa, Middle East, south East Asia, china and Russia. He was informed by **Dr. B. Pattnaik** that the virus lineage may be circulating concurrently in different parts of the world; it is unlikely that virus is transmitted from India, as ecology of the above mentioned countries are different.

**Dr. Nem Singh** raised concern about the disease reporting system and felt the need for



aggressive reporting in order to implement the control programme effectively.

The Chairman enquired about the functioning of ICFMD. **Dr. B. Pattnaik** informed that laboratory research work at ICFMD will be initiated as soon as the live viruses are shifted from Mukteshwar. **Dr. M.V. Subbarao** opined that the International (Exotic) part of the BSL 3-Ag laboratory should be treated as a separate entity with specific mandate and different staff in order to increase its visibility. He also said that the ICFMD facility is having excellent infrastructure but not having sufficient manpower, which needs to be explored for optimum utilization of this state-of-the-art high containment laboratory facility.

ICAR (PDFMD)-PIADC (USDA) Collaborative project on “Understanding FMD viral ecology and landscape epidemiology towards control and eradication” was presented by **Dr R. Ranjan**, Project Investigator with following information.

FMD virus-associated abortion and vertical transmission following acute infection in cattle under natural conditions was diagnosed and described for the first time. The overall NSP-antibody prevalence among cattle dropped from 100% at 3 months post outbreak to 75% at 13 months post outbreak and 25-30 % at 23 months post outbreak. FMD virus persistence in cattle and buffalo upto 7 and 13 months post infection (mpi), respectively, was recorded. There seems to be higher selection pressure on virus genome during persistent infection, which may result in generation of genetic and antigenic variants. Further, the selection pressure acting on viral genomes differ between individual host/animals. Virus clearance with time in both cattle and buffalo was evident from gradual decline in proportion of viral genome and virus isolation positive oesophago-pharyngeal fluid samples (OP fluid).

**Dr. M.V. Subbarao** enquired about availability of any other alternate method other than probang sampling to collect OP fluid to study carrier status. **Dr. R. Ranjan** that informed a few alternate methods are available, but probang sampling is considered as the gold standard.

**Dr J. K. Biswal** presented on development

of New Generation Improved thermostable FMD vaccine virus strain. The existing Foot and Mouth Disease vaccines are heat sensitive and hence to prevent degradation of virus particles, maintenance of cold chain becomes critical and indispensable which is not so easy a task owing to the fact that most of the endemic countries do not have sufficient infrastructure to achieve it. Reverse genetics approach was used for the generation of FMDV serotype O vaccine strain with enhanced thermo-stability. The crucial amino acid residues located at, or very close to, the inter-subunit interfaces of the FMD viral capsid were changed by site-directed mutagenesis technology. This genetically defined/designed FMDV serotype O has enhanced thermostability compared to the parent non-mutated FMDV. Currently, the virus strain is being evaluated by cattle challenge test at IVRI, Bengaluru. The same principle will be applied for the generation of thermostable/tolerant vaccine strains for serotypes A and Asia1.

**Dr. B. Pattnaik** added that the thermostable virus strain is engineered to maintain infectivity as a highly stable virus tend to lose infectivity.

**Dr. A.P. Sahoo** presented a new research project on identification of gene(s) and gene networks to unravel virus-host interactome associated with FMD in cattle. Entry and survival of the microbial pathogen in the host is mediated by a network of molecular interactions between the host and pathogen. This complex interaction between microbial pathogen and its host is the underlying mechanism of the pathogenesis. This understanding will help in developing novel tools for diagnosis, prognosis, and clinical management of FMD. The pathogen–host interactions (PHIs) may be between proteins, nucleotide sequences, metabolites, TLRs, chemokines, and small ligands etc. This project aims to reveal the differential gene expression pattern in host transcriptome in response to FMD virus stimulus, the gene(s) and gene networks involved in FMDV infection in cattle, any novel genes involved in FMDV pathogenesis to establish the cause of occurrence of symptomatic and asymptomatic infections, and the role of miRNA.

In response to this presentation, **Dr. Nem Singh**

stressed for the formulation of research projects that are helpful to the FMD control programme. **Dr. B. Pattnaik** explained that the role of T-helper cells in FMD immunology is largely unknown and this kind of study will help in identifying the molecular interactions and development of better FMD vaccines. **Dr. M.V. Subbarao** opined that the study should be linked to basic immunology. It was decided that for this study, sampling will be done from any indigenous cattle breed.

**Dr (Ms) Smrutirekha Mallick** presented a new research project on development of murine hybridomas and characterization of monoclonal antibodies (Mabs) to FMD virus serotype O. Panel of Mabs will be developed against FMDV serotype O vaccine strain INDR2/1975, which will be used in diagnosis, epitope characterization and mapping

etc.

Though Mabs were developed earlier against all the serotypes of FMDV, several precious hybridoma clones are lost over the years. **Dr. M.V. Subbarao** suggested that besides developing Mabs, the clones needs to be maintained viable and factors associated with making the clones non viable with time should also be studied. **Dr. B. Pattnaik** informed that as per his memory, sometime during 1992-95, some precious hybridoma clones were shared with the International Hybridoma Bank at WRL on FMD, Pirbright.

Honorable Chairman highly appreciated the excellent research output with outcome by a small bunch of young scientists under the leadership of the Director.

The following recommendations were drawn after detailed discussion.

S. No.	Recommendations	Comment of the Director, DFMD	Remarks of the Council
	Laboratory Information Management system (LIMS) need to be implemented in ICFMD	Necessary administrative initiatives will be undertaken for the implementation of LIMS.	Agreed. Initiatives may be taken for functionality of LIMS at DFMD
	ISO 17025 accreditation for both BSL3Ag and BSL2 laboratories of ICFMD need to be obtained.	Necessary administrative initiatives will be undertaken for ISO 17025 accreditation	Noted. Needs to be expedited for both labs BSL2 and BSL3
	DFMD functions as the SAARC Regional Leading Diagnostic Laboratory (RLDL) and this activity needs to be continued in order to maintain visibility of the International Center.	DFMD will continue to function as SAARC Regional Leading Diagnostic Laboratory (RLDL)	Regular training and capacity building for SAARC member countries may be carried out as leading diagnostic laboratory
	A centralized FMD vaccine quality control facility for vaccine testing needs to be created at ICFMD	For this establishment of Animal Experimentation facility at ICFMD is required	AEF is urgently required for vaccine quality control and challenge studies at DMFD
	Entity of the International center should be separate with specific mandate and manpower.	Noted	Noted. Agreed being a specialized laboratory
	The ongoing disease surveillance system and epidemiology should be strengthened with engagement of Biostatistics scientists/consultant.	Noted. Necessary proposal will be made	Agreed
	Strengthening of scientific and support (MTS) man power to fully utilize infrastructure available at ICFMD.	Noted. Necessary proposal will be made	Agreed
	Training programme for SAARC nations on FMD surveillance and monitoring need to be conducted regularly for development of human resources.	Training programme for SAARC nations on FMD surveillance and monitoring will be conducted as per request	Agreed and emphasized in point No 3 also

S. No.	Recommendations	Comment of the Director, DFMD	Remarks of the Council
	Extension activities with FMD awareness camp for farmers need to be conducted regularly	The extension activities for FMD awareness have been conducted by AICRP on FMD regularly.	The extension activities may be taken up on priority and awareness camp for farmers should be conducted regularly
	For operation and maintenance of ICFMD, permanent engineering (technical) posts need to be created, and one bio-engineering consultant should be engaged on contractual basis for smooth running of the high containment laboratory	Noted. Necessary proposal will be made	Agreed owing to the specialized nature of this high containment laboratory
	BSL3-Ag high containment Animal Experimentation Facility (AEF) needs to be established soon that will help in creation of centralized FMD vaccine quality control facility, and also to achieve mandate and functionality of the ICFMD	Necessary administrative initiatives have been undertaken for the establishment of containment animal experimentation facilities.	Noted. Agreed
	Studies on molecular epidemiology of FMD need to be continued	Studies on molecular epidemiology of FMD virus isolates are under taken routinely and further emphasis will be given to cover all the incidences of FMD.	Agreed. Epidemiological studies may be carried out regularly covering all FMD incidences in all areas throughout the country
	The vaccine matching exercise to ascertain the antigenic relationship of the field isolates with the in-use vaccine strains need to be continued	Studies on vaccine matching of FMD virus isolates retrieved from clinical samples are under taken routinely	Agreed and Noted
	Disease Free Zones (DFZs) of FMD need to be created and maintained in and around 20 Km radius of ICFMD, with the maintenance of sentinel animals inside the campus as Bio-Risk measures	DFZ for FMD will be created 20 km radius around ICFMD, Bhubaneswar as per the International norm	Agreed. The sentinel animals may be kept for Bio-risk measures at ICFMD
	Necessary guidelines to be circulated for the investigation of each incidence of FMD with the distinction between an incidence and an outbreak	Regional and collaborative centres of AICRP on FMD have already been intimated. Further staff of ICAR-DFMD also investigate FMD incidences	Agreed. There should be clear distinction between incidence of FMD and outbreak incidence of FMD
	Virus and epidemiological research need to be conducted as a centralized activity at ICFMD	Noted	Agreed
	DFMD being the Regional Leading Diagnosis Laboratory for FMD in South Asia, the Laboratory Directors Meet need to be convened at the ICFMD	Necessary communication will be made to the Regional Support Unit, based in the FAO's Sub-regional ECTAD Unit in Kathmandu	Noted and Agreed
	Seamless operation and maintenance of the engineering establishments of ICFMD and strict implementation of biosafety standards and practices at ICFMD need to be achieved without delay	Noted	Agreed

S. No.	Recommendations	Comment of the Director, DFMD	Remarks of the Council
	Indicator animals need to be housed in the premise of ICFMD as a biosafety and biosecurity measure	Indicator animals will be housed in the premise of ICFMD as per the International norm.	Agreed. Indicator animals may be housed as bio-safety measures
	The mid-term appraisal meeting of the RAC will be held during June-July 2018	Noted	Agreed and Noted

The meeting ended with vote of thanks to the Chair.

## 18.2 Proceedings/Recommendations of the 13th Meeting of the IMC held at ICFMD, Arugul, Bhubaneswar on 19.01.2018

Item No.	Agenda/recommendation of the imc	Comments of the members	Comments of the director	COMMENTS OF THE COUNCIL
1.	<b><u>AGENDA ITEM NO. 1</u></b> Approval of the proceedings of the 12 <sup>th</sup> Meeting of the Institute Management Committee of the Directorate of FMD.	The members expressed their satisfaction over the action taken/initiated on the recommendations of the 12 <sup>th</sup> meeting of the IMC.	Noted	Noted
2.	<b><u>AGENDA ITEM NO. 2</u></b> Presentation on research accomplishments of the Institute. Member Secretary and I/C PME presented the project wise research accomplishments during 2016-17 & 2017-18 along with the prevailing FMD scenario in the country.	Hon'ble members appreciated the sincerity and devotion of scientists for the preparedness to meet real time challenges in controlling FMD for its ultimate eradication. The members expressed their satisfaction on the progress made by the institute in real-time monitoring and surveillance of the disease and the circulating virus strains to maintain the appropriateness of the vaccine. The members were of the opinion to strengthen FMD awareness programme in the Country. The Committee also agreed to the research projects to be undertaken for 2018-19 as approved by the RAC of the Institute.	Noted	Noted
3.	<b><u>AGENDA ITEM NO. 3</u></b> Discussion on RFD for 2015-16 & 2016-17.	Hon'ble members expressed their satisfaction and congratulated the scientists for their significant contribution. They also encouraged the scientists to keep it up in the future also.	Noted	Presently, RFD is not being undertaken at Council.

Item No.	Agenda/recommendation of the imc	Comments of the members	Comments of the director	COMMENTS OF THE COUNCIL
4.	<b><u>AGENDA ITEM NO. 4</u></b> Review of Budget allocation and expenditure for the financial year 2017-18. It was presented by the member secretary which was reviewed by the IMC. Budget utilization till 31 <sup>st</sup> Dec., 2017 was 100%.	The IMC appreciated full utilization of the allocated budget. The Committee suggested for the release of rest of amount of the allocated budget as envisaged in EFC on Capital Head to complete the purchase of essential equipments for ICFMD.	Required fund will be utilized from the "Capital" head.	SMD appreciate effective utilization of funds
5.	<b><u>AGENDA ITEM NO. 5</u></b> Protection of the tilted compound wall in the south side of ICFMD Campus.	An amount of Rs. 78.0 Lakhs (approx.) to be deposited with the CPWD for the protection of tilted compound wall of 505 M length to avoid collapse and any Bio-security threat to ICFMD premises.	Required fund will be utilized from the "Capital" head.	Subject to the provision made in the approved list of EFC/SFC and availability of funds and following all codal formalities
6.	<b><u>AGENDA ITEM NO. 6</u></b> Provision for 2 Lakh litres of potable water supply to ICFMD daily from River Mahanadi Project.	Availability of the required amount of water is essential for ICFMD. So, Rs. 2.1 Crore need to be deposited with the PHED very soon for pipe line connectivity to ensure the water supply by PHED, Govt. of Odisha to ICFMD.	The item is approved in the SFC 2017-20, and work order to PHED will be placed soon by the Institute.	The approval of competent Authority has been conveyed vide Council's letter No AS/4/2/2018-1A.1 dated 15.03.2018
7.	<b><u>AGENDA ITEM NO. 7</u></b> Provision of IT connectivity to ICFMD through BSNL.	The committee suggested for necessary action in this regard as IT connectivity is essential for the smooth operation of the International Centre.	Required fund will be utilized from the allocation under the head "Capital".	Subject to the provision made in the approved list of EFC/SFC and availability of funds and following all codal formalities
8.	<b><u>AGENDA ITEM NO. 8</u></b> Availing of Authorized Medical Attendant (AMA)/facilities at Bhubaneswar/Jatni for ICFMD staff.	The Committee recommended to avail the facilities of Kalinga Hospital at Jatni/Bhubaneswar as the authorized medical facility for DFMD-ICFMD, and also the other medical facilities authorized by the existing ICAR Institutes located at Bhubaneswar/Cuttack can be used.	Noted	Necessary action may be taken as per guidelines.

Item No.	Agenda/recommendation of the imc	Comments of the members	Comments of the director	COMMENTS OF THE COUNCIL
9.	<b><u>AGENDA ITEM NO. 9</u></b> Arrangement for night shelter for night shift workers at ICFMD.	In this regard, the committee suggested to convert and modify the existing temporary tin sheds into night shelters or hire accommodation on monthly rental basis nearby till permanent facilities are developed inside the campus. The furniture & fixtures required for the night shelter also to be provided.	Required fund will be utilized from the allocation under the head "Capital".	Subject to the provision made in the approved list of EFC/SFC and availability of funds and following all codal formalities
10.	<b><u>AGENDA ITEM NO. 10</u></b> Handing over and Taking over of ICFMD from NDDB.	The Committee suggested that the handing and taking over of the completed structures of ICFMD except MLB will take place between NDDB & ICFMD after rectification of the minor defects, snags, and revisit of the Committee of the Works Division of ICAR. The IMC emphasized that the Assets Register need to be completed as per Govt. of India guidelines before taking over the completed structures.	Noted	Noted
11.	<b><u>AGENDA ITEM NO. 11</u></b> Enhanced manpower for housekeeping and security services etc. at ICFMD	Committee observed that ICFMD is state-of-a-art facility in the process of commissioning. Therefore, the required manpower may be engaged as per requirement and necessity.	Noted, and the tender will be floated soon.	Necessary action may be taken as per guidelines and approval is subject to the provision made in the approved list of EFC/SFC and availability of funds and following all codal formalities
12.	<b><u>AGENDA ITEM NO. 12</u></b> Procurement of pick-up van and staff car for ICFMD.	Budget need to be released for the purchase of the 02 vehicles which has been already approved in SFC 2017-20.	The Pick-up van will be utilized for transport of materials within the Campus and outside. The car will be used as the Staff car at ICFMD.	Noted. A separate proposal may be to the Council

Item No.	Agenda/recommendation of the imc	Comments of the members	Comments of the director	COMMENTS OF THE COUNCIL
13.	<b><u>AGENDA ITEM NO. 13</u></b> Requirement of additional Scientific, Technical, Administrative staff for ICFMD.	The Committee recommended for the filling of the post of Asst. Finance & Accounts Officer/FAO by ICAR. Creation of regular technical positions need to be pursued at the Ministry of Finance. Sufficient numbers of Scientists either to be placed/relocated to ICFMD for optimum utilization of the facilities created and to achieve the target and mandates of DFMD-ICFMD. The IMC strongly suggested to build a multi-disciplinary team of Scientists comprising of disciplines of Micro biology, Pathology, Physiology, Genetics and Breeding, Animal physiology and Nutrition, and Medicine etc.	The required regular positions of Engineer/Technical staff (T1 to T6) is also approved by the SFC 2017-20. Currently, Shri Om Veer Singh, AFAO, IVRI, Mukteswar is also looking after the F&A job of DFMD, Mukteswar. However, of late, he has requested ICAR to relieve him from the additional duty of DFMD. At such a juncture, it is requested that one AFAO/FAO is posted at DFMD. Two additional positions of Principal Scientists in the discipline of Vet. Pathology and Animal Genetics and Breeding, and one scientist in Animal Physiology have been approved by SFC 2017-20 to build a multi-disciplinary research team at ICFMD.	As per 0.0. No.41(2)/2005 - Per. IV dt. 26.05.2017, all cases of re-deployment/ transfer/ diversion/ adjustment/up-gradation/re-designation of posts shall be done only with prior approval of MOF. Thus, a separate proposal may be sent to the Council for consideration in the Cadre Review exercise.
14.	<b><u>AGENDA ITEM NO. 14</u></b> Budget 2017-18. [ Rs. in Lakhs ]	There is immediate requirement of 500 Lakhs for procurement of equipment for ICFMD, 210 Lakhs for Mahanadi water supply need to be provided immediately, Rs. 77 Lakhs for repair of boundary wall of ICFMD, and Rs. 93 Lakhs to make ICFMD, ICT ready.	Allocation of funds will facilitate procurement, water supply, works and ICT connectivity to ICFMD.	Subject to the provision made in the approved list of EFC/SFC and availability of funds and following all codal formalities.
15.	<b><u>AGENDA ITEM NO. 15</u></b> Any other miscellaneous issue: Hiring of top notch legal counsel.	The Committee suggested that the Institute may hire top-notch counsels (on merits of case) to defend the Institute/concerned employee.	Currently, the Institute, its Director and one Scientist are defending a false criminal case (filed by a business man) in the Sessions Court, Patiala house, New Delhi since 2015.	A separate proposal may be to the Council/Legal cell as per guidelines

Item No.	Agenda/recommendation of the imc	Comments of the members	Comments of the director	COMMENTS OF THE COUNCIL
	Action taken on the recommendation of the Institute grievance Cell and IJSC.	The Committee suggested that same practice may be continued in future and meetings may be held at regular intervals.	Noted	Noted
	Operation and Maintenance (O&M) of ICFMD.	The committee recommended to extend the service of the existing four Consultants engaged for Civil Engineering, Bio-Safety & PME, Administration and Finance and Accounts till March, 2019. The matter for sanction of the emoluments of Bio-engineering consultant to be obtained from the competent authority i.e. Director of DFMD.	The matter of enhanced emoluments demanded by the selected Bio-engineering Consultant was presented before the 9 <sup>th</sup> meeting of the PMMC, and it was stated that the power to engage Consultant lies with the Director of the Institute. This matter was also discussed in the 19 <sup>th</sup> meeting of the PTC. The Bio-engineering Consultant selected will be engaged soon at a consolidate amount of Rs. 1.25 lac/month.	The proceedings of the 9 <sup>th</sup> meeting of the PMMC and the 19 <sup>th</sup> meeting of the PTC are under consideration of the Competent Authority.

## Scientific

No.	Name of the Staff	Designation	Discipline	Date of Joining ICAR	Date of Joining at DFMD
1	Dr. Bramhadev Pattnaik	Project 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 D.S.Deolia	T-1 (Lab)	16-12-1978	12-01-2012
3	Shri S.L.Tamta	T-1 (Lab)	27-11-1982	19-04-2014

Shri D.S. Deolia retired on 31.10.2017

## 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	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

We express our deep sense of gratitude to Dr T. Mohapatra, Secretary DARE & DG, ICAR; Shri S. K. Singh, AS&FA, DARE; Shri C. Roul, AS & Secretary, ICAR; Dr J. K. Jena, DDG (AS), ICAR and Dr Ashok Kumar, ADG (AH), ICAR for providing all the necessary financial and infra-structural facilities and providing the guidance. We are thankful for untiring help and support of Principal Scientists

(AH) on various matters. We are also thankful to Director, IVRI for necessary support provided at Mukteswar. Untiring effort of a small group of young scientists in achieving new milestones at the institute is praise worthy. We also wish to express our appreciation to the administration, audit, account and technical supporting staffs of the Directorate for their excellent assistance in achieving targets.

**Inauguration of ICAR-ICFMD by the Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India Shri Radha Mohan Singh on 01.04.2017 at Arugul, Jatni, Bhubaneswar**



**Inauguration of Administrative block of ICAR-ICFMD by Dr. T. Mohapatra, DG, ICAR and Secretary, DARE on 25th Jan, 2018**



**Inauguration of BSL-2 facility in Main Laboratory Building of ICAR-ICFMD by Shri Chhabilendra Roul, Secretary, ICAR and Addl. Secretary, DARE on 25th Jan, 2018**



**8th PMMC (project management and monitoring committee) meeting held at ICAR-ICFMD, Arugul on 25th January 2018 under chairmanship of Shri Chhabilendra Roul, Secretary, ICAR and Addl. Secretary, DARE in presence of Dr. T. Mohapatra, DG, ICAR and Secretary, DARE**



**8th RAC meeting of DFMD, held at ICAR-ICFMD, Arugul on 18th January 2018 under chairmanship of Dr. R.N.S. Gowda, Former VC, KVAFSU, Bengaluru**



**Visit of Dr. T. Mohapatra, DG, ICAR and Secretary, DARE and Shri Chhabilendra Roul, Secretary, ICAR and Addl. Secretary, DARE and Dr J.K. Jena, DDG, AS on 25th January 2018**



## Visit of Dr. T. Mohapatra, DG, ICAR and Secretary, DARE and Shri Dilip Rath, Chairman, NDDDB to ICAR-ICFMD, Arugul



## Inauguration of Transmission Electron Microscope Facility of ICAR-ICFMD by Shri Chhabilendra Roul, Secretary, ICAR and Addl. Secretary, DARE on 23th Jun, 2018



**Visit of Dr. Jimmy Smith, DG, ILRI and Dr. H. Rahman, Regional Representative for South Asia, ILRI to ICAR-ICFMD on 20th June, 2017**



**Visit of Dr. Mangala Ray on visit 22th Sept, 2017**



**Visit of Dr. Joykrushna Jena, Deputy Director General (Animal Science) to ICAR-DFMD, Mukteswar on 25th June, 2017**



**Visit of Prof Dr. Satya Parida, The Pirbright Institute, UK on 22nd December, 2017**



**Dr Vish Nene, Programme director, Vaccine Bioscience, ILRI**



### Visit of OIE team to ICAR-ICFMD, Arugul on 23rd February, 2018



### Visit of OIE team to ICAR-DFMD, Mukteswar 16th April, 2018



### Visit of OIE team to ICAR-ICFMD, Arugul 27th June, 2018



## Plantation by dignitaries during visit to ICAR-International Centre for Foot and Mouth Disease, Arugul, Bhubaneswar-752050, Odisha



Dr. T. Mohapatra, DG, ICAR and Secretary, DARE



Shri Dilip Rath, Chairman, NDDDB



Dr Mangla Rai, Ex-DG, ICAR



Dr. J K Jena, DDG, AS, ICAR



Dr Vish Nene, Programme director, Vaccine Bioscience, ILRI



Prof Dr. Satya Parida, The Pirbright Institute, UK

### Hindi Saptah from 14-20 September 2017



### Swachh Bharat Abhiyan 2017-18



### Vigilance awareness week 2017-18



### FMD Awareness Camps organized at villages of Darima and Ritha, District Nainital



## ICAR-Directorate of FMD participated in Krishi Unnati Mela - 2018 organized at IARI Mela ground during 16-19 March 2018



## ICAR-DFMD participated in Kisan Mela organized by VPKAS Almora on 11th October, 2017



## GFRA-2017 meeting at Incheion South Korea      Rashtriya Gaurav Award



BSL-2 corridor



Anteroom with shower of BSL-3

## Laboratory at ICFMD, Arugul



# ICAR-ICFMD, ARUGUL CAMPUS



हर कदम, हर डगर  
किसानों का हमसफर  
भारतीय कृषि अनुसंधान परिषद

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