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Foot and mouth disease vaccine response in cattle: A review

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Abstract
India is the largest milk producing country of the world. To sustain number one position, reduction in production due to diseases like Foot and mouth disease is essential. The disease has debilitating effects, including weight loss, decrease in milk production and loss of draught power resulting in loss of productivity for a considerable time. Immunization of cattle has been considered as a standard management practice for disease prevention. However, not all animals respond equally to vaccinations and there might be various genetic and non-genetic factors responsible for this variation viz., cohort, season, vaccination number and status of the animal etc. This review in short elucidates the effects of these factors on FMD viral vaccine-elicited immune response in cattle. The variation in vaccine response needs to be exploited on large-scale animal data for better immunization and protection against highly contagious viral vesicular disease of cloven-hoofed animals.

Keywords: Foot, mouth disease vaccine, cattle

Introduction
In India, dairy industry contributes 3.97% to agricultural gross domestic products. India is the leading milk producer in the world (132 MT, DAHD-2011) [2]. In order to sustain this position and to meet the global food demand, reduction in production due to diseases i.e. (Foot and mouth disease) is kept under stringent control. Foot and Mouth disease is one of the most important animal diseases affecting international trade in livestock, meat and other animal products. In India, the disease is responsible for direct and indirect economic losses estimated at about 4300 crore of rupees annually (Anon, 1991) [1]. The animals from which the FMD virus is recovered at or beyond 28 days post-infection from oropharyngeal fluid (OPF) are called carrier animals and these may be responsible for outbreaks of the disease in contact susceptible animals (Sutmoller *et al.*, 2003) [14]. Furthermore, development of persistent infection does not depend on the immune status of the animals, both naïve animals and vaccinated animals exposed to live virus may develop persistent infection (Salt, 1993) [11]. Infection of susceptible cattle with FMD Virus results in a rapid rise in serum antibody which can be detected from around four days post-infection. This early antibody is largely IgM and relatively heterotypic and peaks at around 10 to 14 days before declining to low levels within 30 to 40 days (Salt, 1993) [11]. After 7-10 days IgG gradually predominates which is highly serotypic specific and important in eliminating infection. Foot and mouth disease virus have direct effects on the production of the affected animals which summed over the individuals, constitute the impact of the disease at the herd level and are manifested as changes either in herd productivity and/or changes in the herd structure (Manjeet *et al.*, 2017). Thus, the effect of disease has to be seen in the context of its impact at the herd level. Dairy animals affected by FMD are estimated to lose one third (33%) of their lactation production. Fertility is affected through a delay in conception and increased abortions. It is estimated that 10% of pregnant animals affected by FMD will abort and that on average this will occur half way through gestation followed by a six month delay in conception and mortality rate will be 1% amongst affected non-descript cattle and 2% amongst cross-bred cattle (Ellis and Jamies, 1977). Calf mortality is around 33% in unweaned calves affected by FMD. The permanent damage to productivity caused by FMD will lead to culling of 3% of affected non-descript and 5% of crossbred cattle (Ellis and Jamies, 1977). The effects of disease on the growth rate are estimated as a delay in reaching maturity. This delay is estimated as two months in non-descript and three months in cross-bred cattle. The disease has debilitating effects, including weight loss, decrease in milk production and loss of draught power resulting in loss of productivity for a considerable time.

Response to FMD vaccine

Immunization of cattle has been considered as a standard management practice for disease prevention, and remains one of the most effective methods for disease prevention (O'Neill *et al.*, 2006; Richeson *et al.*, 2008) [8, 10]. Vaccination has been shown to improve animal health and productivity by reducing disease incidence as animals move through production phases. Optimization of vaccination protocols to decrease disease prevalence provides an opportunity to reduce these losses. Vaccination has many benefits for disease prevention and overall health status of animals.

Antibody response to vaccination in mammals are complex polygenic traits modified by host genetic factors and environment (O'Neill *et al*., 2006) [8]. Not all animals respond equally to vaccinations. There is considerable variation among animals in their response to infectious disease and vaccination (Poland *et al*., 1998; Davies *et al.,* 2007) [9, 3]. There might be several genetic and non-genetic factors responsible for this variation (Downey *et al*., 2011) [4].

Vaccine response due to genetic and non-genetic factors

Cohort

Leach *et al.,* (2010) [7] reported significant effect of cohort (cohort corresponding to year of birth of animal) in Holstein-Charlois cattle for response to FMD vaccine. Gowane *et al.* (2013b) [5] also reported significant effect of cohort in crossbred cattle on the vaccine-elicited immune response for serotype O and non- significant for serotypes A and Asia1.

Season

Gowane *et al.* (2013b) [5] reported that season of vaccination had significant effect on vaccine response due to serotype A and Asia 1 in crossbred cattle, whereas, season did not have any significant effect on the vaccine response due to serotype O. They observed that September/October (post-monsoon) vaccinated animals had better protection level as compared to that of March (spring or post-winter) vaccinated animals for serotype A, whereas, March (spring or post winter) vaccinated animals performed better as compared to that of September/October (post monsoon) for serotype Asia1. Manjeet *et al.* (2017) observed the effect of season of vaccination and it was found significant for post AB titre for serotype Asia1.

Vaccination number

Leach *et al*. (2010) [7] reported that the older animals had significantly higher immune response for FMDV peptide vaccine, suggesting that even in older animals immune system might still be developing.

Gowane *et al.* (2013b) [5] reported that effect of number of vaccinations on the FMD vaccine response was highly significant for serotype O, whereas, it was significant for serotypes A and Asia1. They observed that as the number of vaccination increased, the ß exponential for the outcome of protection against serotype O also increased; it was highest for vaccination numbers 4, 6, and 7. Similarly for serotype A, vaccination number 7 showed highest odds of protection and for serotype Asia1, ß exponential was high for second, third, and seventh vaccination number. They also observed decline in the response after eighth vaccination for all the three serotypes.

Status of the animal (dry, milch and calves)

Gowane *et al.* (2013b) [5] revealed that cows in their first trimester of lactation did not elicit good protection against FMDV vaccine, whereas those in later phase of lactation as well as non-lactating were comparatively better protected. Differences were, however, non-significant for serotype O and significant for serotypes A and Asia1. Manjeet *et al.* (2017) studied the effect of status of animal and it was significant for all the pre and the post AB titres except for pre AB titre of serotype O and post AB titre of serotype Asia1. Post AB titre for serotype O was the highest for the adult animals (dry and milch both) and the lowest for calves.

Age

Scholium *et al.* (1985) [13] reported that 6-month-old calves responded three times higher to vaccination than 3-month-old calves. Samina *et al*. (1998) [12] conducted a study on Israeli Friesian bulls and observed significant effect of age of the animals on the immune response to trivalent FMD vaccine (O1, A22, and Asia1).

A significant effect of age of the animals on antibody response to FMD vaccination in the Holstein-Charolais cattle was also reported by Leach *et al.* (2010) [7]. The older animals had significantly higher immune response for FMDV peptide vaccine.

Downey *et al*., (2011) [4] reported that calves should to be at least 130 days of age to elicit a positive response to vaccination. Gowane *et al*. (2013b) [5] found significant increase in percent protected animals from animal age ranging from one to 5 years or more for all the serotypes O, A, Asia 1. They also reported decline of vaccine response in reported animals which included mostly lactating animals.

Heritability estimates of response to vaccination:

Gowane *et al.* (2013b) [5] estimated heritability for FMD vaccine response for serotypes O, A, Asia1 as 0.17, 0.03 and 0.05 respectively indicating low to moderate estimates of heritability for FMD vaccine response. Manjeet *et al.* (2017) estimated heritability for response to vaccination and it was from low to high ranging from 0.11 to 0.45. The highest heritability estimate was obtained for response to serotype O and the lowest for response to Asia1. The heritability estimates for pre and post AB titres ranged from 0.15 to 0.33, being the highest for post AB titre of Asia1 (0.33) and the lowest for post AB titre of serotype A (0.15).

Conclusion

Foot and mouth disease (FMD) is the most contagious and painful disease of mammals and a major threat to animal husbandry sector. In India, vaccination with the inactivated trivalent (O, A and Asia1) vaccine is one proven way for protecting the livestock from FMD. However, many outbreaks have been reported in different parts of the country. The present review in short elucidated the effects of genetic and non-genetic factors on FMD viral vaccine-elicited immune response in cattle. The variation in vaccine response which needs to be exploited on large-scale animal data for better immunization and protection against highly contagious viral vesicular disease of cloven-hoofed animals. FMD vaccine-elicited immune response in cattle is affected by a range of factors including environmental factors such as season of vaccination and year of vaccination and genetic factors such as age of animals, vaccination status and heritability estimation.

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