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Research Article

Cattle Immune Response to the Foot and Mouth Disease Vaccine in Siyari Rural Municipality Rupandehi

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Abstract

Foot and Mouth Disease (FMD) is a common issue in Nepal, posing risks to livestock, leading to frequent outbreaks and economic loss. The disease spreads through various secretions of infected animals, and factors like livestock movement within the country and across borders contribute to its prevalence. Poor nutrition and herd management practices further increase the risk. The current inactivated Foot-and-Mouth Disease (FMD) vaccine poses challenges in terms of logistics and cost. In this research, we processed and tested the serum of vaccinated cattle from Siyari Rural Municipality for FMD antibodies. We used the Anigen Rapid FMD NSD Ab test kit to detect FMD NSD antibodies and the FMDV NS Ab ELISA to detect FMD SD antibodies. The results showed that none of the tested cattle (0/80) had FMD NSD antibodies, indicating no natural infection. However, 30% of the population (24/80) tested positive for FMD SD antibodies, revealing that only a portion of the cattle developed detectable antibodies after FMD vaccination. For FMD vaccination to be effective, 80% of the population must be immune to the illness. The findings suggest that the current immunization program against FMD in Siyari Rural Municipality is not achieving the desired level of immunity, as only 30% of the cattle population exhibited detectable antibody titers post-vaccination. This insight highlights the need for reevaluation and improvement of the FMD immunization strategy in the municipality.

Keywords: Cattle; Vaccination; Immunity; Antibody; FMD

Introduction

Background Information

Foot-and-mouth disease (FMD), which is brought on by the FMD virus (FMDV; Aphthovirus, Picornaviridae), affects domestic animals with cloven hooves as well as several wildlife species all over the world [1,2]. Symptoms of acute infection include fever, ptyalism, lameness, vesicles, and erosions in the mouth, on the feet, and in the teats [3].

The FMD virus is present in various bodily fluids such as saliva, semen, milk, urine, and feces of infected animals [4] Close contact with affected animals poses a risk of FMD transmission. Infection may occur through abrasions in the skin's mucous membrane [5].

Following a clinical or sub-clinical Foot-and-Mouth Disease Virus (FMDV) infection, the persistence of infection occurs at a similar rate in both vaccinated and unvaccinated animals [6-8]. Approximately 50% of animals infected with FMDV may become long-term carriers, hosting the infectious virus for over 28 days. This carrier state, which can endure for 2-3 years in clinically healthy animals, presents a potential risk of transmitting the infection to other animals [9,10].

FMD is endemic in Nepal, as it is in many underdeveloped nations. The illness has been recorded in all 77 of the nation's districts, and laboratory testing has verified it in 74 of them (National FMD and TADs Laboratory). Four of the seven viral serotypes (O, A, C, and Asia 1) have been identified from FMD cases in Nepal since 1965 (Ferris et al. 1992).

FMD outbreaks occur throughout the country, regardless of altitude or climate. The incidence of the disease is throughout the year, however, is higher during the monsoon and post-monsoon seasons [11].

Movement of livestock within the country particularly during the holiday seasons of Dashain and Tihar, as well as the legal and illegal trade of animals between India and Nepal [12] and the presence of small ruminants and animal markets [13] contribute to the high frequency of FMD outbreaks in Nepal.

Initiated in 2012, Nepal's National FMD Control Program initially targeted the Eastern and Far Western Development Regions before expanding nationwide (Acharya K.R. (2015) FMD and Farming Practices in... - Google Scholar, n.d.). Since the Nepal Veterinary Production Laboratory (NVPL) has not yet produced the FMD vaccine domestically, importation is necessary. In 2018–19, approximately 2.4 million FMD vaccine doses were imported, marking a 90% increase from five years prior (Veterinary Standards and Drug Regulatory Laboratory, n.d.).

Problem and justification

The detection of animals infected with Foot-and-Mouth Disease Virus (FMDV) is vital for FMD control, especially in nations with no widespread outbreaks.

In 2015, FMD accounted for 22.6% of disease outbreaks and 3.7% of deaths in Nepal (FMD Newsletter-Nepal FMD Situation in Nepal, n.d.), resulting in substantial economic losses from reduced milk and meat output, neonatal deaths, and trade restrictions (Perry et al., 2002; Rushton, 2003).

FMD caused estimated annual losses of 66 million US dollars in terms of decreased milk and meat production (Gongal: Foot and Mouth Disease in Nepal - Google Scholar, n.d.). When factoring in veterinary care, reduced animal draught power, and diminished reproductive efficiency, actual economic losses may be considerably higher.

As a World Trade Organization (WTO) member, Nepal faces challenges in international livestock and animal product trade, particularly cattle products, due to widespread FMD presence (Thakuri K. (2012). Status of Animal Disease Outbreak... - Google Scholar, n.d.) (Stenfeldt., *et al*., 2016) (Stenfeldt et al., 2016). Detection of infected or recently immunized animals is crucial for trading [9,11]. as non-symptomatic carrier animals aid in FMD transmission.

Objectives

General objective

Improving Cattle Herd Health Through Effective FMD Vaccination

Specific objectives

- Detection of FMD NSP Antibody
- Detection FMD SP antibody
- Effect of Time period after Vaccination on immunization
- Effect of body condition and nutrition on immunization.

Limitation of Study

- Absence of proper farm record-keeping.
- Language barriers impeding effective communication.
- Insufficient knowledge among farmers.
- Reluctance to provide blood samples for analysis.

Literature Review

The development of an ideal Foot-and-Mouth Disease (FMD) vaccine is a complex endeavor. A perfect vaccine, as envisioned, would offer effective protection after a single dose, be Differentiating Infected from Vaccinated Animals (DIVA) compatible, negate the need for a cold chain, be economically viable for mass production, and remain affordable for consumers [14].

There is currently no universal vaccination that can provide protection against all serotypes of the virus due to the high level of antigenic diversity in FMDV. In fact, certain strains of the same serotype may not be cross-protected by existing vaccines [15,16].

Existing vaccines, particularly those containing chemically-inactivated components, have demonstrated success in disease control but require biannual boosting [17-22].

In the process of viral replication during infection, both structural proteins (SP) and immunogenic nonstructural proteins (NSP) are synthesized [23]. At least after a limited number vaccines virtually exclusively produce antibodies against the virus's SP. Notably, antibodies against NSPs can potentially differentiate between vaccinated and diseased animals [24].

In endemic regions, semi-annual mass vaccination is practiced, while non-endemic areas employ ring vaccination around outbreak zones as a supplementary measure to depopulation plans [25].

The main component of FMD vaccines is purified, chemically inactivated whole viral preparations.

Challenges include the necessity for high-containment facilities to grow large virus quantities, continuous modification of vaccine strains, and the temporary nature of protection (4-6 months) [15].

Strengthening vaccinations has been explored to extend the protective range [26,27].

Additionally, the logistical challenge and expense of cold chain delivery make vaccine distribution in endemic regions difficult.

In various countries, chemically inactivated FMDV vaccines are employed to combat the enzootic nature of FMD [28]. While progress has been made, the quest for an ideal FMD vaccine continues to face multifaceted challenges.

Material and Methods

Study Area

The study will be conducted in the Sirari Rural Municipality in Rupandehi District in Lumbini Province of western Nepal. It is located at 83.401469°" east longitude and 27.566241°" north latitude. This district covers a total area of 66.17 square kilometers.

Method

Cross-Sectional

Study Population

Cattles from commercial cattle farms

Sample size

- Population of cattle in Rupandehi: 74,66,841
- Estimated prevalence: 34.65%
- Precision: 0.05
- Confidence:0.95
- Calculated sample Size: 10
- To make result more accurate sample size was increased eight times so Sample Size: 80

Sampling procedure

- Commercial cattle farms of Siyari Rural Municipality selected randomly
- 5 cattle from each farm were collected randomly.

Sample collection

- Blood was collected 3 [29] 6and 6 months [30] after vaccination.

Study design

- Animals vaccinated against Foot-and-Mouth Disease (FMD) were identified.
- Blood was collected from the jugular vein using a clot activation tube (Yellow top).
- The collected blood was centrifuged to separate the serum.
- The serum was then transferred to an Eppendorf tube and stored in a frozen state before analysis.
- FMD Non-Structural Protein (NSP) antibodies were detected using the Rapid FMD NSP Antibody Test kit (Robiolo et al., 2006).
- FMD Structural Protein (SP) antibodies were detected using the FMD SP Antibody ELISA (Robiolo et al., 2006).

Result

FMD NSP and SP antibody detection test

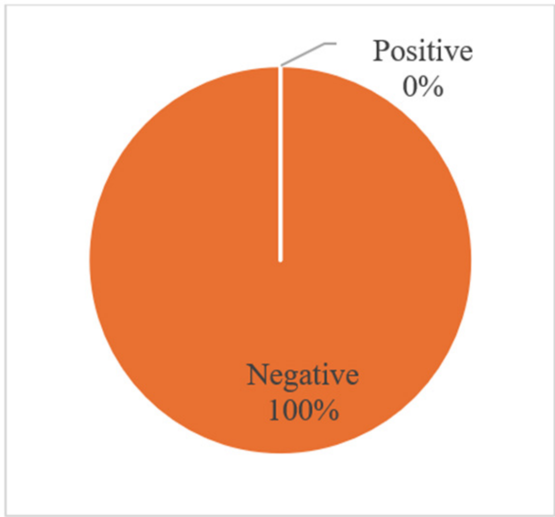

Figure 1: Result of FMD NSP antibody test.

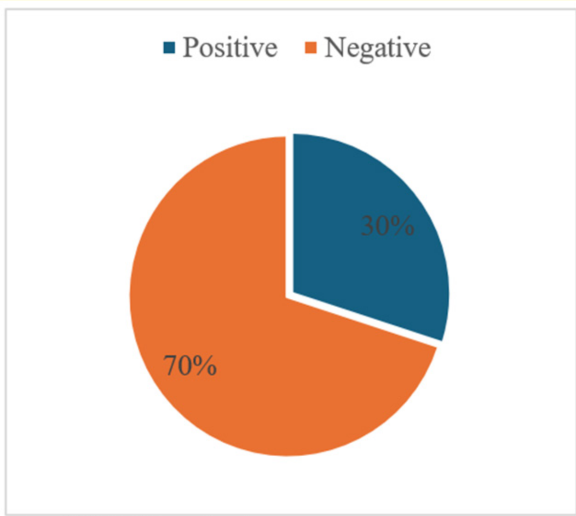

Figure 2: Result of FMD SP antibody test.

SP and NSP protein detected in sample as done by [31].

None of the examined samples showed evidence of FMD NSP antibodies, indicating the absence of natural infection or carrier stages of FMD. Out of the entire set of samples, 24 out of 80 tested positive for FMD SP antibodies. This finding suggests that only 30% of the samples had developed immunity to FMD through vaccination, rendering them immune to the disease.

Effect of Time Duration on FMD Immunization

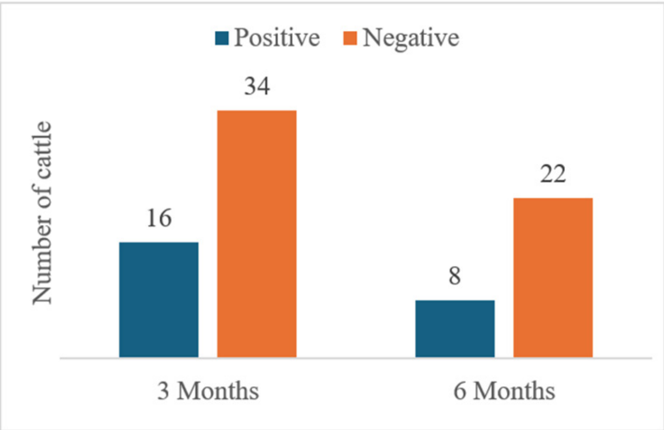

Figure 3: The dispersion of FMD SP test results over a period of three and six months.

Fifty samples were gathered three months post-FMD vaccination [29], and an additional 30 samples were collected six months after vaccination [30]. Among the samples obtained in the third month, 16 out of 50, equivalent to 32%, tested positive for FMD SD antibody. In contrast, of the samples collected in the sixth month, 8 out of 30, or 26.66%, were found positive for FMD SD antibody. These results suggest a higher immune response three months after vaccination compared to six months, as supported by [32].

Effect of body condition FMD Immunization

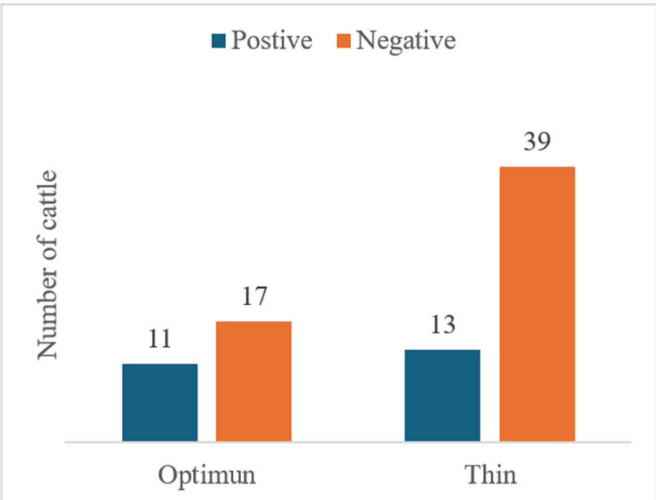

Figure 4: The dispersion of FMD SP test results over optimum and thin body condition.

Among the cattle assessed, 28 out of 80 (35%) were determined to be in optimum body condition, while the remaining 52 out of 80 (65%) were identified as being in thin body condition. Interestingly, 11 out of the 28 (39.28%) healthy cattle tested positive for FMD SD antibodies, in contrast to only 13 out of 52 (25%) thin cattle showing positive results in the FMD SD antibody test. This observation implies that the immune response is higher in the population with optimum body condition compared to those in thin condition, a conclusion supported by [33].

Effect of feed supplementation on FMD immunization

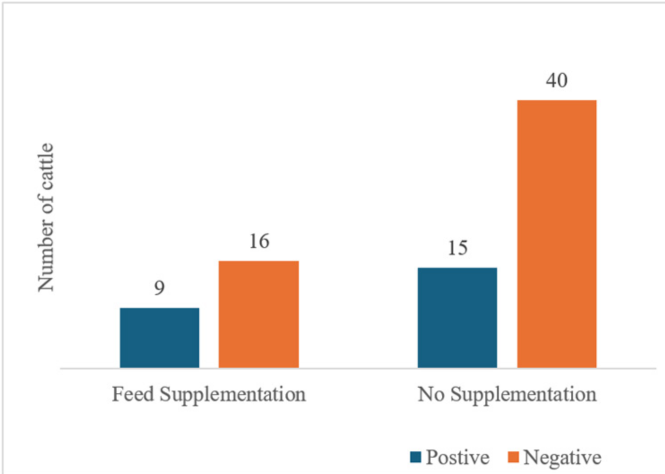

Figure 5: The dispersion of FMD SP test results over Feed supplementation and no supplement.

Among the cattle assessed, 25 out of 80 (35%) were determined to be supplemented with feed, while the remaining 55 out of 80 (68.75%) had no supplementation. Interestingly, 09 out of the 25 (36%) feed supplemented cattle tested positive for FMD SD antibodies, in contrast to only 15 out of 55 (27.27%) cattle with no supplementation showing positive results in the FMD SD antibody test. This observation implies that the immune response is higher in the population with feed supplementation compared to those with no supplementation, a conclusion supported by [34].

Discussion

Achieving full protection within the herd is a challenging, if not unattainable, goal. Nevertheless, it has been approximated that achieving herd immunity at a level of 80% or higher, with a vaccine strain closely aligned with the field strains, would confer safeguarding against clinical outbreaks of Foot-and-Mouth Disease (FMD) [33-36].

Vaccines should be able to stimulate potent and long-lasting immunity after a single dose. It has taken a great deal of research and effort to improve vaccines for foot-and-mouth disease (FMD) and to understand host immune responses to FMD infection in order to develop vaccines that promote potent, long-lasting immunity to FMD [37-39]. Low-potency FMD vaccines, which are widely used, cannot provide immunity that lasts beyond six months, depending upon the type and quality.

To prevent the decrease of protective antibody levels to non-protective values, naturally infected calves should have a second vaccine 36 weeks after the first vaccination, and vaccinated calves should receive a third vaccination 32 weeks after the initial vaccination [40] as well as the re-vaccination is required between one and three times per year, depending on the epidemiological situation [41].

Supplementation proves to be an effective stimulant for enhancing the production of total Foot-and-Mouth Disease Virus (FMDV)-specific antibodies [42].

The robustness of the immune response is intricately tied to the overall health and well-being of individuals. Put simply, maintaining good health and self-care tends to strengthen the immune system. Factors such as a nutritious diet, regular physical activity, and overall wellness play a pivotal role in the effectiveness of the immune system. The intensity of the immune response is significantly impacted by the individual's body condition [43].

Conclusion

Nepal faces considerable challenges in controlling Foot-and-Mouth Disease (FMD) due to governmental limitations such as low resources, a shortage of educated personnel, poor infrastructure, and restrictive regulations on cattle slaughter and access to high-quality vaccines [13].

Efforts to address FMD involve the development of vaccines capable of eliciting potent and durable immunity with just a single dose. Extensive research and dedication have been invested in improving FMD vaccines and understanding host immune responses to FMD infection [37-39]. Notably, commonly used low-potency FMD vaccines may offer immunity for only up to six months, depending on their type and quality.

The strength of the immune response is closely tied to an individual's overall health and well-being. Essentially, maintaining good health by practicing a balanced lifestyle, including proper nutrition, regular physical activity, and general well-being, has proven to enhance the immune system's effectiveness. This emphasizes the crucial role lifestyle factors play in supporting a robust immune response.

Additionally, the use of supplements emerges as a valuable strategy to reinforce the body's defenses, especially against the Foot-and-Mouth Disease Virus (FMDV). These supplements provide additional nutrients, aiding the immune system in generating more antibodies specialized in combating FMDV. This supplementation serves as an extra layer of support, enhancing the body's natural defense against the virus.

Recommendation

Enhancing immunization against Foot-and-Mouth Disease (FMD) is crucial, as the existing approach generates an immune response in only 30% of the studied population, falling short of the desired effective immunization threshold of 80%. Therefore, a thorough analysis of FMD immunization is imperative to formulate a more effective immunization protocol.

Consideration should be given to adopting a biannual vaccination schedule rather than relying solely on a single-dose vaccine to optimize the effectiveness of the current vaccination strategy.

Furthermore, improving husbandry practices is essential for enhancing overall herd health, including factors such as body condition and nutrition. This holistic approach can contribute significantly to achieving better outcomes in FMD prevention and management.

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